



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN OF PNEUMATIC GRIPPER FOR COMAU
ARTICULATED ROBOT**

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

by

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ABSTRACT

This project report presents the work done on the designed of pneumatic gripper for COMAU articulated robot in the Robotics Laboratory, Faculty of Manufacturing Engineering, UTeM. The objectives of this project are to design the pneumatic gripper and to develop a soft prototype for the designed gripper. Three design ideas are proposed. The ideas are compared base on some criterias in order to select the best idea. The selected idea is developed using the proposed methodology. The selected idea has been developed using CATIA software. The list of all parts that need to be fabricated and the standard parts are presented in this report. The detail of the gripper parts and their specifications are presented in solid model with the dimensions which are fulfilled the requirement for further development of the gripper. Finite element analysis (FEA) has been used to analyze the gripper design. The stress, displacement, deformation and factor of safety are obtained from the analysis and presented. All of the project objectives are managed to be achieved. For future work it was suggested to fabricate, install, and test the designed gripper and also improve the design of the gripper. The design of the gripper should be improved (if necessary) base on the test result.

ABSTRAK

Laporan projek membentangkan kerja yang dilakukan pada pencengkam pneumatik yang direka untuk COMAU robot di Makmal Robotik, Fakulti Kejuruteraan Pembuatan, UTeM. Objektif projek ini adalah untuk mereka bentuk pencengkam pneumatik dan membangunkan prototaip lembut untuk pencengkam yang direka. Tiga reka bentuk yang telah dicadangkan. Idea-idea ini dibandingkan berdasarkan beberapa kriteria untuk memilih idea yang terbaik. Idea dipilih dibangunkan menggunakan metodologi yang dicadangkan. Idea dipilih telah dibangunkan dengan menggunakan perisian CATIA. Senarai semua bahagian yang perlu direka dan bahagian-bahagian yang standard dibentangkan dalam laporan ini. Lukisan model dan spesifikasi pencegkam telah dibentangkan dengan ukuran yang yang terperinci bagi memenuhi keperluan untuk membangunkan lagi pencengkam. Analisis unsur terhingga (FEA) telah digunakan untuk menganalisis reka bentuk pencengam. Tekanan, anjakan, ubah bentuk dan faktor keselamatan yang diperolehi daripada analisis dan dibentangkan. Kesemua objektif projek yang telah berjaya dicapai. Untuk kerja-kerja masa depan ia dicadangkan untuk mereka-reka, memasang, menguji dan pencengkam direka dan juga memperbaiki reka bentuk pencengkam. Reka bentuk pencengkam perlu diperbaiki (jika perlu) berdasarkan hasil ujian.

DEDICATION

I would like dedicate this report to my lecturer, technician, my family and my friends for helping during the research activities. There is no doubt in my mind that without their continued support and counsel I could not have completed this project.

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LIST OF ABBREVIATIONS,SYMBOLS AND NOMENCLATURE

COMAU	-	COnsorsio MAcchine Utensili
CAD	-	Computer-Aided Design
3D	-	Third Dimension
CAM	-	Computer-Aided manufacturing
FEA	-	Finite Element Analysis
Kg	-	Kilogram
Mm	-	Millimetre

CHAPTER 1

INTRODUCTION

1.1 Introduction

Pneumatic system is a system that functioned to transmit and control energy using compressed air. In a pneumatic system, energy is stored in a potential state under the form of compressed air . Pneumatic actuators are capable of providing high power output levels at a relatively low cost (Liu, S. & Bobrow, J.E, 1988). Many industries have equipped their production lines with compressed air such as in the robotic arm tooling application. Besides, it can be said that the pneumatic system is relatively clean, lightweight and environmentally friendly. In addition, the pneumatic system has the advantages with both good performance and low cost with the proposed controller (Shih, M.C.&M.A, 1998). Usually for open loop system application such as robot arm tooling (grippers), pneumatic system are often being used. The standard robot gripper can be divided into two motions which are angular or parallel used as a part of pick and place system that used to pick workpieces and placed it at the other side in their range of axes (Saeed,N., 2010). Some of the robot grippers are driven by the different types of drive system such as pneumatic, hydraulic, electric or spring power (Shimon Y. N., 1999).

Gripper can be distinguished in terms of the shape of the gripping surfaces or jaws, the amount of force that can be applied and the opening size of the jaws. The shape of the robot gripper can be chosen according to the shape of the objects that are to be manipulated (Ong Rong San,2013).Basically, the robot gripper used a sensor to control the amount of force that need to be applied to the object that need to be gripped while some grippers used air pressure to act directly to the object that they are gripped. This project is aimed to design a pneumatic gripper for COMAU articulated robot in Robotics Laboratory of Faculty of Manufacturing Engineering (FKP) at Universiti Teknikal Malaysia Melaka (UTeM). The design should be suitable for pick and place application for the robot.

1.2 Problem Statement

The present robot gripper for the COMAU articulated robot in Robotics Laboratory of Faculty of Manufacturing Engineering, UTeM need to be redesigned because it is not suitable for handling cylindrical shape of workpieces above 1 kg. The gripper is designed for handling of rectangular workpieces below 1 kg weight For handling of cylindrical workpieces with higher weight, a stronger gripper need to be designed.

1.3 Objectives

- i. To design a pneumatic gripper for COMAU Articulated Robot.
- ii. To develop a soft prototype of the above designed pneumatic gripper.

1.4 Project Scope

- a) To design a pneumatic gripper for COMAU Articulated Robot using Computer Aided Design (CAD) software to meet the following requirements:
 - i. The gripper can handle cylindrical shape of workpieces having diameter up to 50 mm.
 - ii. The gripper can handle a cylindrical shape of workpieces having weight up to 5kg.
 - iii. The workpiece will not slip from the gripper fingers

- b) To develop a soft prototype of the designed pneumatic gripper using a suitable 3D CAD/CAM software.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses about information related to this project in order to give well understanding and good review about things that are crucially needed. This chapter also includes the study on the existing robot gripper available with the COMAU robot in FKP's robotic laboratory. Besides that, the previous research from other people that related with this project is also

2.1 Definition of robot

In general, robots are designed and meant to be controlled by a computer or similar device. The motions of the robot are controlled through a controller under the supervision of the computer, which running some type of a program. Robots usually is used to do work or perform the required tasks which previously done by human. Robots are very powerful elements of today's industry. Different countries have different standards for what they consider a robot. Robotic Institute of America states that a robot is a reprogrammable, multi-functional manipulator that designed to perform tasks that previously done by human. A robot, as a system, consists of the following elements which are integrated together to form a whole. The elements are manipulator, end effector, actuators, sensors, controllers, processor and software (Saeed,N.,2010). The basic robot arm geometry can be categorized in terms of their geometrical shapes which composed of cartesian, cylindrical, spherical and articulated arm. This research study

will look more into detail concerning about the articulated robot because this project is based on that type of robot. The next subtopic will briefly explained about the COMAU articulated robot and it's specifications.

2.1.1 COMAU Articulated Robot

The guideline of the design is made by using the current COMAU Articulated robot manual which is available in laboratory. The COMAU articulated robot used in this research is SMART NS type series 16-1.65 (COMAU Robot Manual, 2005). Smart NS robots occur in various type of application that focused mostly in robotic field. Characteristics of SMART NS family come in highly modular design and referred as the similar operating rules such as in work envelope, payload and reach. Figure 2.1 shows the current COMAU Articulated robot in FKP.



Figure 2.1: SMART NS 10-1.65, COMAU Articulated robot
(Source: Image taken from Robotic Lab, at FKP Block B)

It is very vital to choose the robot application when obtaining the maximum payload. Robot payload is the load or weight for a certain robot arm can lift. Robot payload also refers to the weight of the gripper. Table 2.1 below shows the robot specifications.

Table 2.1 : SMART NS Specifications

VERSION	PAYLOAD	REACH
SMART NS 16-1.65	16 kg (<i>32.27lb</i>)	1650mm (<i>64.96lb</i>)

Besides that, there are some characteristics of the robot that are important to consider in order to design the suitable gripper specifications as shown in Table 2.2.

Table 2.2: Characteristic and performance

VERSION	NS 16-1.65
Structures / axis	Anthropomorphous / 6 axis
Load at wrist	16kg (<i>35.27lb</i>)
Additional load at forearm	10kg 22.04lb
Maximum horizontal reach	1650 mm (<i>64.96in</i>)
Robot weight	335 kg (<i>738.54lb</i>)
Repeatability (mm)	+/- 0.05 mm (<i>0.0019in</i>)
Total power installed	3 kVA / 4.5 A

The operating area also can be one of the crucial part in designing a gripper of a robot because based on the manual the operating area shows the where the gripper functioned during task. Figure 2.2 and 2.3 shows the operating area of the COMAU Articulated robot.

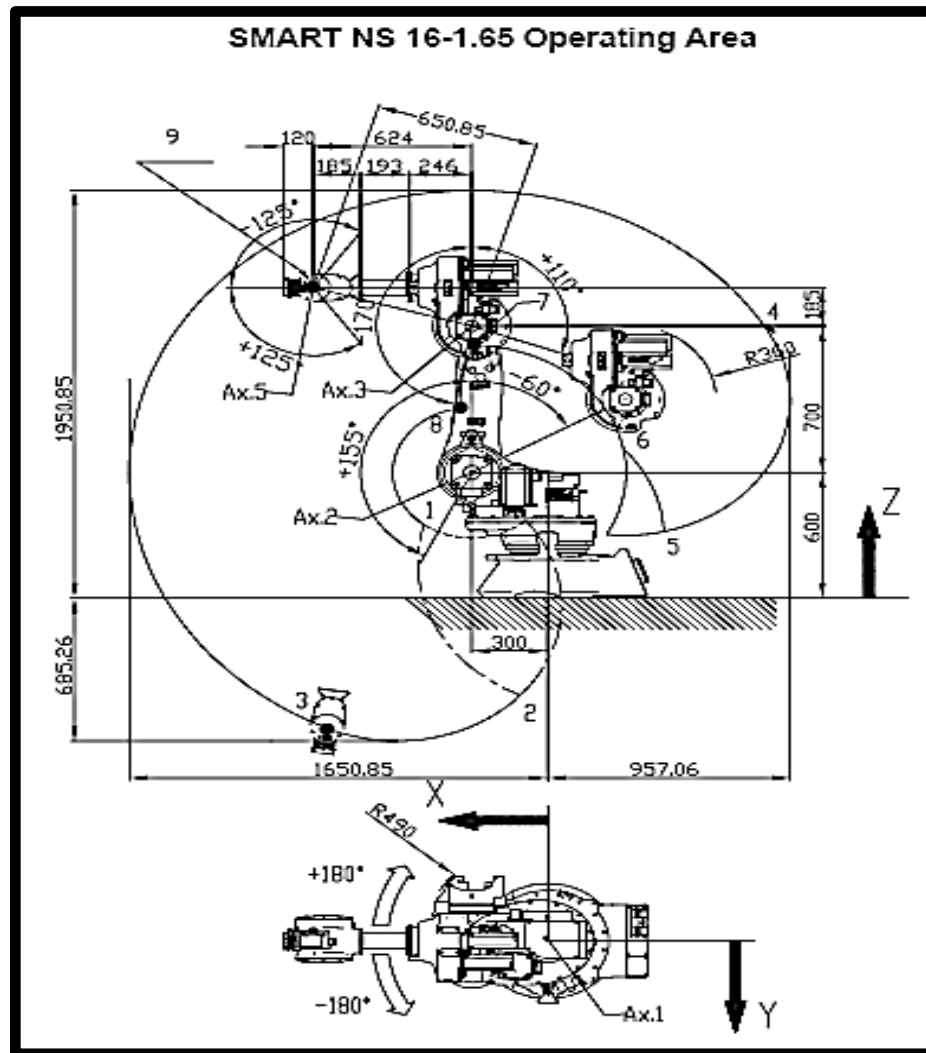


Figure 2.2: Top and side view of COMAU Articulated robot
 (Source: Manual of Comau SMART NS technical specification)

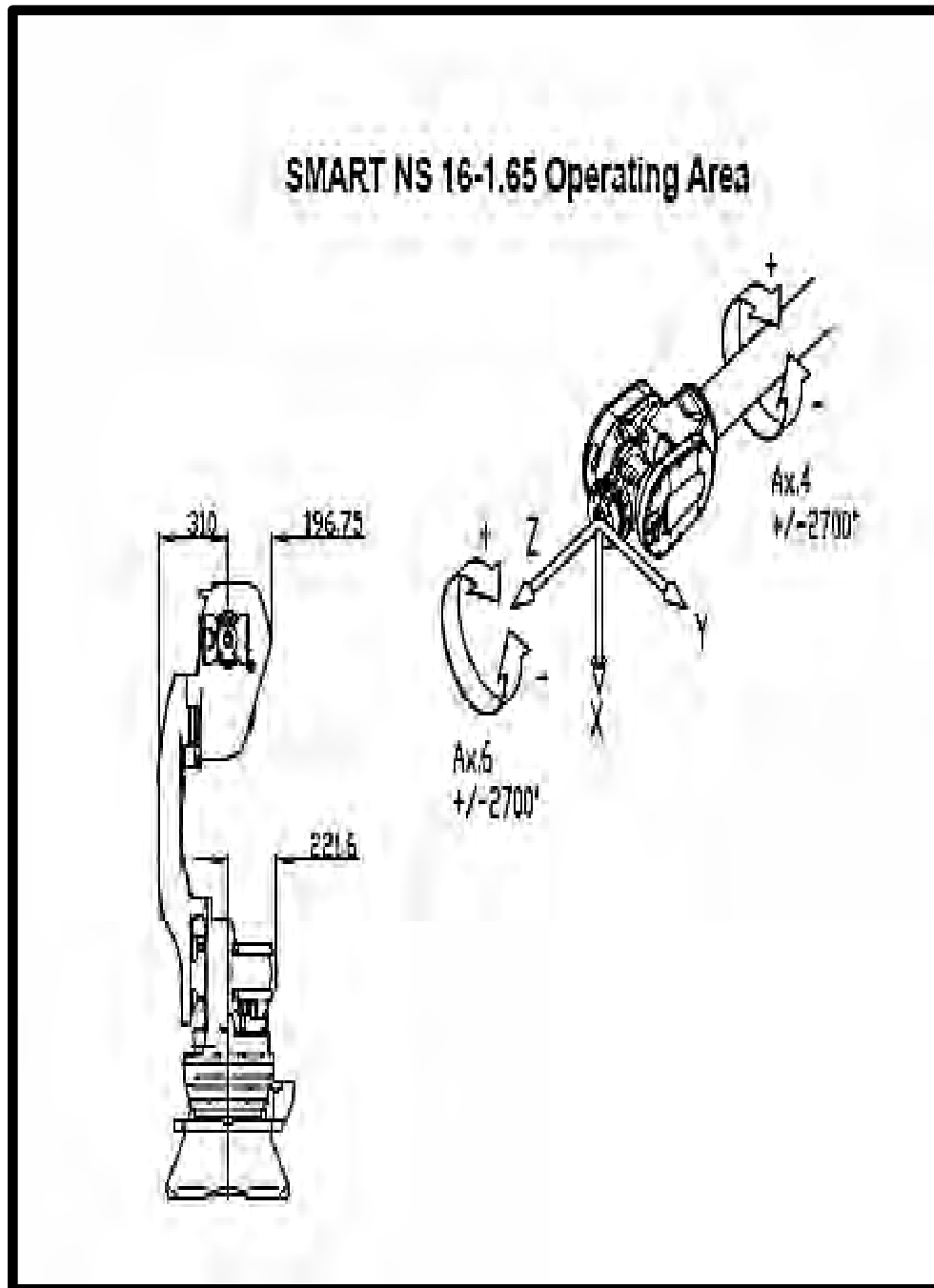


Figure 2.3: Front view of operating areas and overall dimension of SMART NS 16-1.65 (Source: Manual of Comau SMART NS technical specification)

2.2 Grippers

Grippers or end effectors are the main component in the robotic system application in order to pick and place object or workpieces within its range of axes. So it is important to design the gripper with the first class type of gripper. Omega defines that a gripper is a device that holds an object so it can be manipulated (Omega,2014). The grippers has the power to grip and release the object while some other tasks is performed. Each arm of robot must being constructed with their own degree of freedom (DOF). DOF is meant by each link and joint must has their limit of size and movement. Moreover, the robot working envelope must be reachable by the DOF of the gripper depend on its angle and configuration of the robot.

2.2.1 Definition and Conceptual Basic of Robot Gripper

The gripper is the only part that has the mechanical contact with the objects and its main functions are to grip objects, hold objects and release objects. Gripping establishes a defined position and orientation of the object relative to robot during the holding secures the defined position and orientation relative to a robot during the material route and assembly operation (Rembold,1990). Robot grippers are a type of end effector used to move parts from one location to another (Groover, et al.,1986). The gripper is also defined as a device to grasp or hold the workpiece during the work cycle (Mittal & Nagrath, 2003). They can be driven by hydraulic, electrically and pneumatically.

The application that usually involved gripper include material handling, machine loading-unloading, palletizing, and other similar operations (Mittal & Nagrath, 2003). The object to be grasped and the task to be performed are crucial in determining the shape and size of the gripper and the method of holding. Although gripper is also a type of tools, but it is more specifically according to its purpose.

Standard gripper can have two different closing motion which is angular and parallel. The gripper can be categorized into 3 major types which include magnetic gripper, vacuum gripper and mechanical gripper (Rembold, 1990)

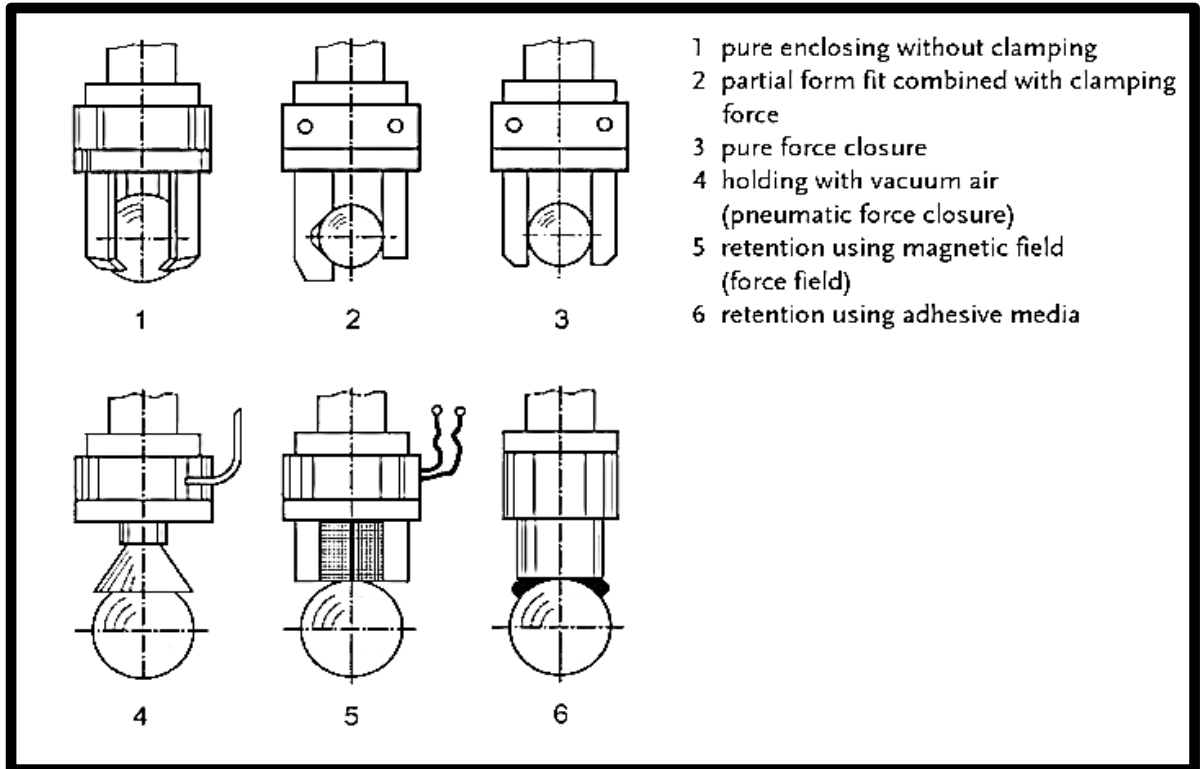


Figure 2.4 : Possibilities for prehension of a spherical object (Monkman,2006)

There are three usual forms (impactive, astrictive and contigutive) of object prehension in six different as shown in figure 2.4. The grasping force is determined by energy required for the mechanical motion leading to a static prehension force (Monkman,2006)

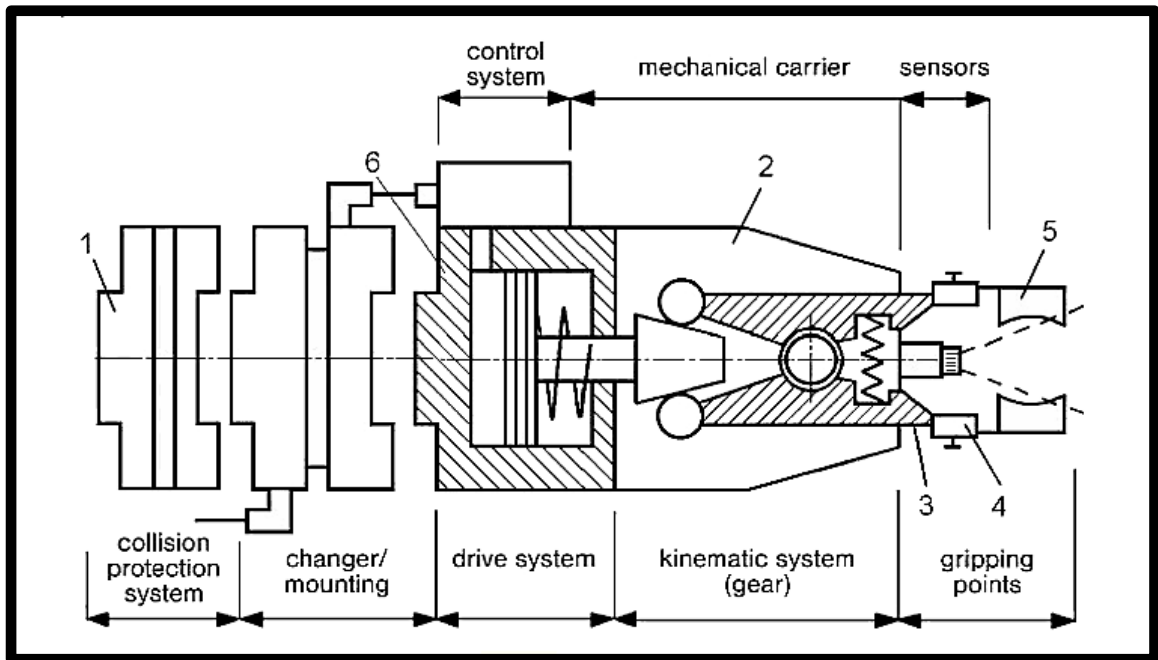


Figure 2.5 : Subsystem of mechanical gripper (Monkman,2006)

Gripper can be equipped with sensors such as shown in Figure 2.5 as a gripping point for supervising the gripping functions. A structured sensor system can supervise the internal state of a gripper(for example, finger distance) and the structure of the environment (for example, workpiece distance) The functional model of a gripper is modelled as shown in figure 2.6.

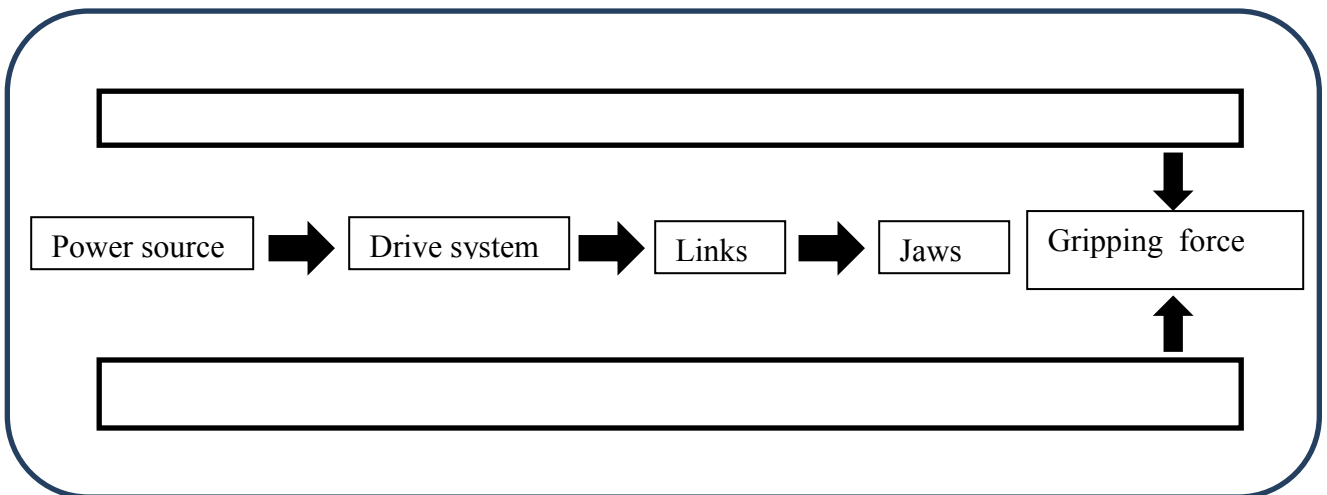


Figure 2.6 : Functional model of the gripper