THE DESIGN AND FABRICATION OF HYDRAULIC BOOM TRAINER WITH GRIPPER ATTACHMENT

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This report is submitted in partial fulfilment of the requirement for the degree of Bachelor of Mechanical Engineering (Thermal-Fluids) with Honours

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)"

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Date : ....

DECLARATION

"I hereby declared that the work in this report is my own except for summaries quotation which have been duly acknowledged"

Signature : ………………………..

Author : MUHAMMAD FAIZ BIN OTHMAN

Date : JUNE 2013

This report is dedicated to my family. Thank you for your continuous support during my vital educational years. Without their patience, understanding and most of all love, the completion of this work would not have been possible.

To my beloved mother,

Noraini Binti Suhaimi

My siblings,

Emran Affendy Bin Othman
Norazlin Binti Othman
Norhasniza Binti Othman
Norhaslina Binti Othman
Norhashima Binti Othman
Muhammad Faizal Bin Othman

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"In The Name Of Allah, The Merciful, The Beneficent"

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ABSTRACT

Manipulator arm is a mechanical system that shows the movement of a robot that consists of a composition link and joint which capable to form a controlled movement. The application of this fabricated manipulator arm is connected to existing hydraulic training system in laboratory as the source of system controller. The process involved in completing this project consists of literature review, projection and angle of motion review, blueprint design using SolidWork Software, kinematics analysis, component procurement, fabrication and model testing. The model testing is done by using pneumatic and hydraulic system as the system controller where the movement testing and cylinder speed testing are conducted. Movement testing indicates that the movement of manipulator arm by hydraulic system is more stable and moving constantly than pneumatic system. Next, the cylinder speed testing is performed where the operating pressure was setup from 4 bar to 8 bar for pneumatic system while for hydraulic system was setup from 10 bar until 30 bar. The result shows that the time taken for cylinder speed by using pneumatic system is slower and not moving constantly than hydraulic system since the behavior of air is compressible and also affected by the gravitational and load factor. Therefore, the most suitable system for this project is by using hydraulic system and in term of application, this project can be further developed and improved in order to fulfill the requirement for the future development.

ABSTRAK

Lengan penggerak adalah satu sistem mekanikal yang menunjukkan pergerakan robot yang terdiri daripada pautan komposisi dan sendi yang mampu untuk membentuk satu pergerakan terkawal. Aplikasi lengan penggerak ini direka dan disambungkan kepada sistem latihan hidraulik yang sedia ada di makmal sebagai sumber pengawalan sistem. Proses yang terlibat dalam menyiapkan projek ini terdiri daripada kajian ilmiah, unjuran dan kajian pergerakan sudut, reka bentuk menggunakan perisian *SolidWork*, analisis kinematik, pembelian komponen, fabrikasi dan ujian model dimana ia terdiri daripada ujian gerakan dan ujian kelajuan silinder. Ujian gerakan menunjukkan bahawa pergerakan lengan penggerak menggunakan sistem hidraulik adalah lebih stabil dan lancar berbanding sistem pneumatik. Seterusnya, ujian kelajuan silinder dilakukan dengan tekanan operasi bermula dari 4 bar ke 8 bar bagi sistem pneumatik manakala bagi sistem hidraulik bermula dari 10 bar ke 30 bar. Hasil kajian menunjukkan masa yang diambil untuk kelajuan silinder dengan menggunakan sistem pneumatik adalah lebih perlahan dan tidak lancar berbanding sistem hidraulik kerana faktor mampatan udara dan juga faktor graviti dan beban. Oleh itu, sistem yang paling sesuai untuk projek ini adalah dengan menggunakan sistem hidraulik dan bagi tujuan aplikasi, projek ini boleh terus dibangunkan dan diperbaiki untuk memenuhi keperluan pembangunan masa hadapan.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

According to Esposito (2009), fluid power is the technology which involves the use of pressurized gas or fluid in order to generate, transmit and control power. Nowadays, fluid power is one of the major technologies that been applied in almost factory in the world weather in heavy industries or in small industries and also been applied in non-industry sector such as in medical and food processing sector. Besides that, fluid power technology is one of the subject that been though in schools and institutions of higher education. There are a lot of application that used this technology such as fluid power steer and brakes automobiles, offshore, launches spacecraft, drives machine tools and mines coal. The application of fluid power technology is useful in order to perform a certain work that could not be done by human capability. For example lifting heavy load, movement limitation, pull and push heavy load and regulate almost all machines in industries which directly make a work easier and faster. In fact, there is almost all worldwide manufactured that hasn't been used this technology at specific stage or at certain level in their production or distribution.

Fluid power is divided into two main systems which are hydraulic system and pneumatics system. Hydraulic system used a pressurized liquid such as oil and water as a working fluid and pneumatic system used a compressed air as source of power. Both system works with specific equipment and component for the system to be functional based on require purpose. In this paper, the project proposed is related with hydraulic system where actually has two difference types which is fluid transport and fluid power transmit. Fluid power transport is used in delivery a fluid or liquid from one place to another that mostly considers the total amount of transported fluid. Then, fluid power transmit is designed in order to perform a specific work according to require purpose. This type of hydraulic system used a pressurized liquid to transmit power that been generate from hydraulic power unit and been supply to the cylinder for a linear motion and fluid motor for a rotary motion. Figure 1 shows the application of hydraulic system in lifting a load.

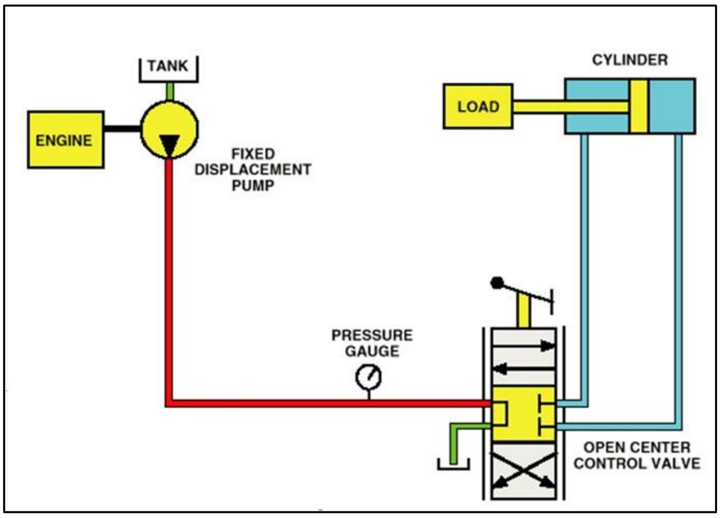


Figure 1.1 Hydraulic System
(Source: http://prayitnoagus.blogspot.com/)

In addition, the application of hydraulic system also been applied for educational and research purpose. The example of a hydraulic system application for educational and research purpose is hydraulic boom trainer or also known as hydraulic manipulator arm trainer. Actually, hydraulic manipulator arm is one of the application that been used in most industries with various scale and size. The purpose of this application is to react as a human arm in order to do a work with a certain limitation and system configuration. There are various types of manipulator arm for educational and research purpose such as KUKA youBot and Robotnik. The development of the manipulator arm for research and educational purpose is getting rapidly expanding due to widespread usage of manipulator arm application in industries or non-industries. Therefore, this project is proposed which required a design and fabrication of hydraulic manipulator arm or boom trainer for educational and research purpose.

1.2 PROBLEM STATEMENT

By referring to Luca & Sicilianot (1993), in reducing costs and improving capability and efficiency of work in the production of a product, the approach of using hydraulic manipulator arm applications is enhanced and expanded. Hydraulic system is one of the subjects in engineering courses in institutions of higher education and the basic of this system also been taught in schools. Hydraulic training kit that commonly used in schools and institutions of higher education only provide the basic equipment, component and tools. Therefore, this hydraulic boom trainer project is proposed in order to provide additional components for hydraulic training kit for future development.

1.3 PROJECT OBJECTIVE

The objective of this project is divided into several specific points:

i. To design and fabricate hydraulic boom or manipulator arm trainer with the concept of gripper attachment with various angle movements which consists of five hydraulic cylinders for the purpose of education and research.

ii. To conduct a testing which is includes the discussion and analysis on smoothness of the movement, angle of motion and cylinder speed.

1.4 PROJECT SCOPE

The scope of the project is used to show the limitation of the research and give the clearest view of the project. In this project, there is several scope of study involved which is:

i. To design and fabricate a small scale of manipulator arm system for educational purpose or as a training kit.

ii. To develop a manipulator arm system that will be fitted on a portable table and connected with current hydraulic power trainer in Hydraulic and Pneumatic Lab, FKM, UTeM.

iii. To test and compare the performance of the boom trainer using maximum pressure of 30 bar, with different working medium, involving pneumatic and hydraulic oil.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION TO MANIPULATOR ARM

In Koivo (1989), the word "robot" comes from the Czech word "robota" meaning work. Meanwhile, according to Webster's dictionary, robot is defined as a robotic device that shows the functions of human behavior. A more complete definition developed by the RIA (Robot Institute of America), they said robot is a programmable multifunctional manipulator reset (multifunctional reprogrammable manipulator) designed to move material, equipment or appliance. According to Craig (1986), degree of freedom (DOF) is the linear motion or rotation along or around the axis at the manipulator arm. In the case of industrial robots, manipulator arm is an open circuit and each joint position is usually determined by a single variable which means the number of joint is equal to the number of DOF. Faris et al. (2012) emphasized that degrees of freedom is the maximum number of variables needed to define the motion of an object and movement resulting from the joint manipulator arm. Joint between the two arms were connected to formed by its nature as a joint revolute (rotary) or prismatic (slide). Figure 2.1 displays the (3) three DOF of manipulator arm. Other researcher Iqbal et al. (2012), stated that in process of modeling a manipulator arm, the solutions by using inverse kinematics should be taken into consideration when constructing and facing with numerous DOF in order to obtained the best analytical solution. Inverse kinematics is able to evaluate the needed equivalent joint angle based on preferred position and angle of motion of the manipulator arm end effector.

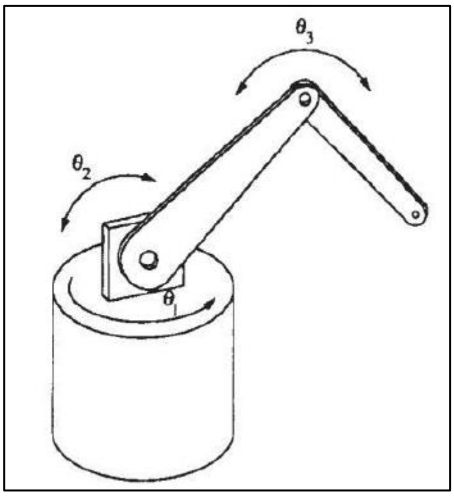


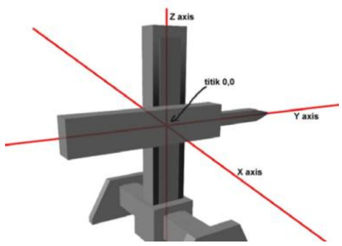
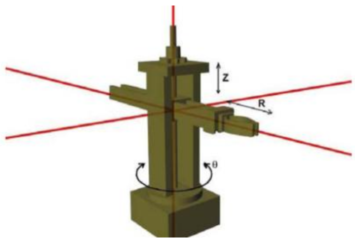
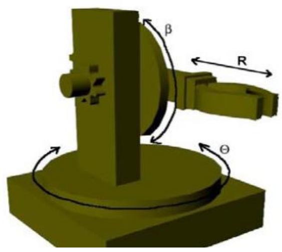
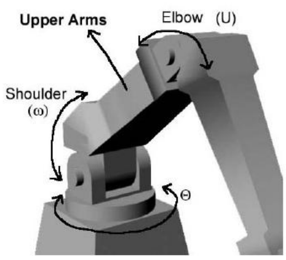
Figure 2.1 Manipulator Arm with (3) three degree of freedom
(Source: (Faris et al. 2012))

By referring from previous research Hemami (1988), human arm has (7) seven degree of freedom which capable to do a lot of works with high flexibility of movement while mostly there are only (5) five to (6) six degree of freedom of manipulator arm that already exist in industries. However, human arm has high limitation of doing heavy job and workspace limitation. Therefore, the purpose of developing robotic manipulator arm is to react as a human arm in order to do the works that beyond human capabilities. Robotic manipulator arm has been widely applied in the world industry, such as welding robot, handling robot, punching and cutting robot, machine tools robot and also widely applied for research and educational purpose.

There are various type of manipulator arm which is applied various configuration depending on the level of difficulty of the task or works. This manipulator arm has the advantage of flexibility in the (2) two dimensional work area space so that it is suitable to be applied in most industrial robots. In order to carry out their duties, it needs a planning system movement of the manipulator from the initial conditions to the final conditions in accordance with the tasks that have been given. There are several algorithms that have been raised by some experts to plan the movement of the manipulator to accomplish a task that has been given.

According to Budiono et al. (2011), some things that underlie the use of robot is that the robot has many advantages that humans do not have such as produce the same output when working a task repeatedly. So it can be re-programmed functioned for several different tasks and has low percentage of mistakes than humans make, as well as numerous other benefits. However, the movement of the robot control artificial intelligence sometimes still has limitations in some cases such as for more actual movement or more flexible that it is still necessary control is done manually. Due to the variety of shapes and sizes, the manipulator arm also has a variety of movement skills. Physically, there are several configurations can be formed. Most of manipulator arm possess (1) one of the (4) four basic configurations which are polar configuration, cylindrical configuration, Cartesian configuration and Jointed-arm configuration. Table 2.1 shows the figure of manipulator arm configurations.

Table 2.1: Manipulator Arm Configuration

Cartesian Configuration: Based on 3-axis or plane, the axis is x, y and z.	
Cylindrical configuration: Comprised of 3-axis, consisting of θ represents the rotary axis and z axis represents the movement up and down along the R axis which represents the movement of elongated or shortened.	
Polar configuration: It also has a 3-axis which is θ, β, and R. This system is symmetrical because the latitude of robot sphere (ball).	
Articulate configuration: Defined by 3-axis, θ (theta), upper arm (w) and elbow (U). Wick provides the greater flexibility.	

(Source: http://didiktristianto.dosen.narotama.ac.id)

In the meantime, due to the rapid development of the use of manipulator arm as one approach to make work become easier and faster, the knowledge about the usage and advantages of manipulator arm was introduce starting from earlier education in school. In schools, most of the project on constructing a manipulator arm is using syringe to react as a cylinder and also as a controller to move the manipulator arm. The purpose of this concept is to discuss and analyze the principle of fluid power which is use the under pressure fluids to generate, control, and transmit power. In Sobh et al. (2001) research, most of student in schools were only exposed to the theoretical lesson and spend a lot of time in classroom. Most of the time, they could not adopt and apply practically what they had learn in class in order to analyze result and won't be able to discuss and doing comparison between theoretical and experimental result. The existing manipulator arm either using pneumatic, hydraulic or servo motor as the main source of power generally is quite expensive and large in size. Besides, the systems of the existing products are more complicated and too sophisticated to be analyzed by student in schools and universities. By developing and constructing the manipulator arm for educational and research purpose which is small in size and with the system that not too complicated, student will be able to understand and learn about the functionality of the system and the main concept of the design. Figure 2.2 shows the example of hydraulic manipulator arm using syringe.

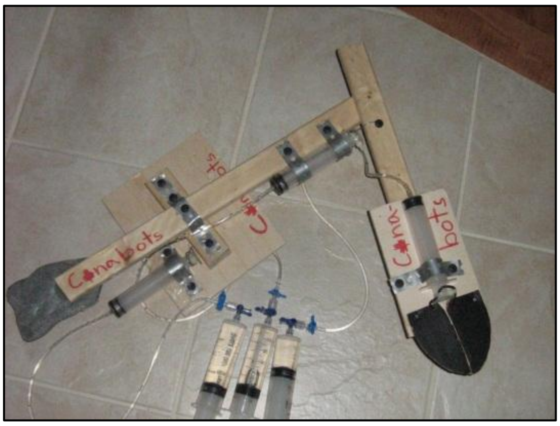


Figure 2.2 Manipulator Arm using Syringe
(Source: http://www.cse.iitk.ac.in/users/amit/courses/768/00/atandon/)

In institution of higher education such as Universiti Teknikal Malaysia Melaka (UTeM) specifically in Faculty of Mechanical Engineering (FKM), there is a hydraulic training kit in laboratory that been provided for student to learn about the hydraulic system which consists of specific components and tools. The model of this training kit is DS34 Training system which been supplied by Rexroth Bosch Group from Germany. The features of this training kit are to provide training system for basic and advanced due to practical requirement. The main components are consists of stable, steerable castors with integrated hydraulic power unit, an electrical switch box, a tool container, a measuring glass, and a P/T distributor. Therefore, the idea of this project is proposed in order to give other alternative method in learning process and to clearly understanding the application concept that relate to the hydraulic system. Figure 2.3 shows the actual DS4 Training System in FKM Laboratory.

Figure 2.3 DS4 Training System

2.2 MANIPULATOR ARM FOR EDUCATIONAL AND RESEARCH PURPOSE

In previous research by Sobh et al. (2001), they had developed concurrent design of a three-link manipulator prototype. They explained the steps on how to produce the proposed prototype in efforts to expand the manufacture on prototyping development for educational and research purpose. Indirectly, they also want to provide a practical approach amount student in order to give the opportunity for them