DEVELOPMENT OF
LOW PRESSURE WATER HYDRAULIC SYSTEM

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"I hereby declared that I have read this thesis an in my opinion this thesis is sufficient in terms of scope and qualify for the award of the Degree of Bachelor Mechanical Engineering (Design & Innovation)"

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"I hereby declared that this is my own work except the ideas and summaries which I have clarified their sources"

Signature : ……

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Special dedicate to

my family, supervisor, my friends, and all that help me to finish my thesis.

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ABSTRACT

This thesis presents a study of developing a low pressure water hydraulic system. This study mainly focuses on building up a water hydraulic power unit, design and assembles a low pressure water hydraulic testing system and performs the testing procedures to testing system. The ultimate goal of this project is to apply the low pressure water hydraulic system into an existing Pick and Place Robot. The combination of water hydraulic application and pneumatic application will be shown in the robot. Water hydraulic system is not so common in industries sector compare to pneumatic system and oil hydraulic system. This study may help to explore the limitation of water hydraulic system and the countermeasure to solve the occurred problems. A testing system was designed and simulated by using Automation Studio 5.0. From the simulation, the motion of cylinder was shown. This can help in assembling the testing system correctly and help in time efficiency. Several tests were done with the aid of the stated testing system. These tests are focused on the actuator of the system, which is a double acting cylinder. The performance of system was tested in term of breakaway pressure, internal leakages, speed of stroke and output force. The results were recorded and analyzed to verify the ability of low pressure water hydraulic system. As a result, low pressure water hydraulic system is applicable. However, improvements are needed to make the system more suitable and efficient.

ABSTRAK

Tesis ini menerangkan kajian tentang pembangunan sistem hidraulik air tekanan rendah. Kajian tertumpu kepada pembinaan unit kuasa hidraulik air, mereka bentuk dan memasang sistem pengujian hidraulik air tekanan rendah dan menjalankan tatacara menguji terhadap sistem pengujian tersebut. Matlamat utama projek ini adalah untuk melaksanakan sistem hidraulik air tekanan rendah kepada *Pick and Place Robot*. Penggabungan aplikasi hidraulik air dan aplikasi pneumatik akan ditunjukkan dalam robot tersebut. Penggunaan sistem hidraulik air adalah kurang dalam sektor industri berbanding dengan sistem pneumatik dan sistem hidraulik minyak. Kajian ini dapat mengetahui had sistem hidraulik air dan penyelesaian untuk mengatasi masalah yang berlaku. Sistem pengujian telah direka bentuk dan simulasi telah dilakukan dengan menggunakan *Automation Studio 5.0*. Pergerakan silinder telah ditunjukkan dalam simulasi tersebut. Ini dapat membantu dalam pemasangan sistem pengujian dengan betul dan meningkatkan kecekapan masa. Beberapa ujian telah dilaksanakan dengan bantuan sistem pengujian tersebut. Ujian ini ditumpukan terhadap penggerak sistem, iaitu silinder dua tindakan. Prestasi sistem yang diuji adalah seperti tekanan lolos, kebocoran dalaman, kelajuan lejang dan daya keluaran. Keputusan telah dicatat dan dianalisis untuk menentukan kebolehan sistem hidraulik air tekanan rendah. Sebagai keputusan, sistem hidraulik air tekanan rendah adalah praktikal. Akan tetapi, beberapa pembaikan diperlukan supaya sistem tersebut lebih bersesuaian dan efisien.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

NO	TITLE	PAGE
5. 13	Electrical Control Circuit	44
5. 14	Stainless steel Pneumatic Cylinder	44
6. 1	Internal Leakage Test	46
6. 2	Test system to collect pressure data.	48
7. 1	Graft of Cylinder Velocity versus Test Pressure	51
7. 2	Test Pressure vs. Output Force	53

LIST OF NOMENCLATURE

A	Cross sectional Area
F	Output Force
H	Height
L	Length
N	Angular Speed
P	Pressure
Power	Power that generated
Q	Fluid Flow Rate
s	Length of Stroke
T	Torque
t	Time
V	Volume
v	Piston Velocity
W	Width

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 OVERVIEW

Water hydraulic system is a fluid power system. Fluid power is the energy generated by using a pressurized medium to accomplish work. A development is carried to study low pressure water hydraulic system. Most hydraulic system use oils as power transmitting medium to work in high pressure, while pneumatic system use air to power actuator in low pressure. Water-based fluids are often been used in hydraulic system due to its non-toxic, non-flammable characteristic to fulfill the hygiene requirement.

This development is about using water as a medium in a low pressure fluid power system. Usually, hydraulic system is design for high pressure application. In this case, pneumatic system which is design for low pressure that works for below 10 bars will be used for testing.

1.2 OBJECTIVE

This project is about developing a low pressure water hydraulic system. The objectives are as follow:-

i) To understand the low pressure water hydraulic system.
ii) To test water hydraulic system at low pressure.
iii) To apply the low pressure hydraulic system to Pick and Place robotic system.

1.3 SCOPE

The scope of the project is generally are as below:-

i) Build a water hydraulic power unit.
ii) Assemble a water hydraulic robotic system.
iii) Testing the uses of water in low pressure fluid power system.

1.4 PROBLEM STATEMENT

Both hydraulic and pneumatic systems are widely used in industries. The common materials used to transfer power in the mentioned systems are oil and air. New materials as pressure medium are developed and water is found as a suitable medium according to its characteristic of non-toxic, nonflammable and no adverse effect on the environment. Several researches and testing were done and proof that water able to be used in hydraulic system as oil can. However, for pneumatic system with low pressure, further development and testing are needed to verify the problem may occurs when water is using.

1.5 PROJECT OUTLINE

This report on “Development of Low Pressure Water Hydraulic System” is divided into 10 chapters.

Chapter 1 introduces the audience to the general background of this research, the problem statement, project objectives, as well as the project scope. Also, it offers an overall view of the project outline.

Chapter 2 is a compilation of required information and literature reviews gathered from electronic media, published journals, and books.

Chapter 3 explains about the methodology used in the study of low pressure water hydraulic system. The methodology consists of 3 main stages; building up the power unit, design the testing system and develop the testing system.

Chapter 4 will present the results of simulation of the designed testing system. This chapter will also discuss related assumptions in validating the simulations.

The development process of low pressure water hydraulic testing system will be explained in Chapter 5.

Chapter 6 will show the results of tests that have been performed.

Chapter 7 will present the results of simulation of the designed testing system.

Chapter 8 will discuss about the findings and analysis of result.

Finally, chapter 9 will present the conclusion and the recommendation for further study in low pressure hydraulic system.

CHAPTER II

LITERATURE REVIEW

This chapter presents a brief review of low pressure water hydraulic system literature which consists of several numerous studies from the past and presents. Beside that, basic theories of fluid power system will be presented in this chapter. These studies are features the theories that are explained application and phenomena of hydraulic system and low pressure fluid power system.

2.1 LITERATURE REVIEW

This section presents the studies on the related literature of Low Pressure Hydraulic System that has been published on a research area. Various journal, books and technical paper have been studied to understand the topic area of this project.

2.1.1 DEFINITION OF LOW PRESSURE

This project carries out a study about a low pressure water hydraulic system. The pressure range in fluid power application may vary a lot. To perform a task that requires small force, the pressure needed may be less than 1 bar. However, for heavy duty industries, the pressure in a fluid power system may up to hundred bars.

According to Alavudeen and Shanmugam (2007), the pressure range in fluid power application is divided into four categories, which are:-

- Low pressure range : up to 10 bar
- Medium pressure range : up to 15 bar
- High pressure range : up to 40 bar
- Ultra High pressure range : up to 400 bar

2.1.2 INTRODUCTION OF WATER HYDRAULIC SYSTEM

The two common power transmitting systems are hydraulic and pneumatic system. Ordinary, oil is used as pressure medium in hydraulic system which operating with high pressure. However, as technology improved, new materials and new design methods were developed, water become a possible pressure medium to be used in hydraulic system. The advantages of water as pressure medium compare to oil are:

- Negligible cost

  The cost of water is relative low compare to mineral oil. Therefore, it is cost effective to use water instead of oil in hydraulic machinery in the long term.

- Non-toxic

  The vapor of mineral oil is harmful to human body. The healthy of workers are at risk to breath in oil vapor or suffer exposure of skin and eyes to the vapor.

- Nonflammable

  Water is fireproof that cannot burn in any condition.

- No adverse effects on environment

  Water is environmentally friendly and does not give any environment hazard.

- Fulfill the hygiene requirement

  There is negligible product contamination in event of leakage of water hydraulic system. The water will simply evaporate without leaving residue when leaks or spills of a water hydraulic system occurred. It has been stated that "As much as 85% of all hydraulic fluid eventually leave their system through slow leaks, catastrophic line breaks or failures of fittings and seals" (Joseph, 1996)

However, there are disadvantages in water hydraulic system. The following shows the inherent disadvantage of water:-

- Corrosion

  According to Krutz and Chua (2004), due to the dissolved gases in the water, the piping and components of the water hydraulic system may face the problem of corrosion. Corrosion resistance materials that are move expensive and even corrosion inhibiting chemicals are needed.

- Lubrication

  Water lacks of the characteristic of lubrication of oil. This poor lubricant characteristic of water makes the water hydraulic system unable to offer faster automation for industrialization.

- Freezing

  Freezing problem occurs on the water hydraulic system that installed outside or in unheated buildings. Krutz and Chua (2004) stated that the volume of water expands by 9% as it freezes. Severe damage may happen in a water hydraulic system. This characteristic of water limits application of water hydraulic system in low temperatures unless water is heated or antifreeze solutions are added.

- Space Requirement

  According to Petraitis (n.d.), the size of water hydraulic components are larger than oil hydraulic components. "The larger component size along with the piping configuration requires a good deal more real estate for installation"

(Petraitis, n.d.). Although some compact model directional control sub-baseplate mounted valves are available in market now, these are limited to a few sizes.

2.1.3 WATER QUALITY

Basically, standards of water quality were determined in the research done by Hilbrecht and Danfoss. The components prescribe in this project are type of stainless steel. In order to prevent corrosion, content of chloride (Cl) must lower than 200 mg/l and water's pH value should be between 6.5 to 8, which in neutral range. (Hilbrecht and Danfoss, 2000)

According to Hilbrecht and Danfoss, raw water is not a suitable type of water to be used in hydraulic system, unless a filter with large filterability is attached to the hydraulic system. The quality of raw water may differ for water from different places. Under a long term visual observation, raw water in Melaka has a poor quality as unknown contaminations often come with raw water.

Based on the research, water quality used in hydraulic system is recommended to be at least drinking water quality with filtration at least 10μm absolute. From the consideration of contamination content, technical water that been demineralized will be the best choice as pressure medium. However, the demineralized water has 2-3 times higher dynamic friction coefficient compare with drinking water. Due to this characteristic, customized component might be needed.

"The acceptable amount of bacteria in water depends on the application of the water hydraulic system in question." (Hilbrecht and Danfoss, 2000)

Drinking quality will be good enough for industries application, whereas high water quality is needed for phama-industries. The germination index (number of bacteria per ml) must be control as low as possible. In order to decrease the germination index, nutritional value should be controlled. Without nutrients, bacteria