DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

Signature :.....
Author :Mohamad Nordin Bin Mohamad Norani
Date :.....

DEDICATION

Dedicated to Allah S.W.T,

My beloved parents,

Mohamad Norani Mansor and Normah Abu Bakar

My siblings that give me support to finish my study at Universiti Teknikal Malaysia Melaka (UTeM)

My beloved lecturers,

My supervisors,

My friends,

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Bismillahirrahmanirrahim

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ABSTRACT

The water hydraulic system is a technology course that uses water as the pressure medium in a hydraulic arrangement. The analysis the water hydraulic hybrid with accumulator concentrate on design phase water hydraulic hybrid with accumulator and without accumulator. The design phase can be categories into 3 sections. First, using FluidSIm simulation to determine the flow and requirement components. Second, modify the water hydraulic system according to the simulation. Lastly, install electrical wiring in the system in order to avoid the short circuit. Besides, the water hydraulic system performance was analyzed by comparing the mechanical, volumetric and overall efficiency using an accumulator or without it. Next, the analysis on the water hydraulic system by increasing pump pressure to effect pressure loss and the system efficiency.

ABSTRAK

Sistem hidraulik air adalah sistem teknologi yang menggunakan air sebagai bahan tekanan dalam sistem hidraulik yang biasanya menggunakan minyak. Analisis hidraulik menggunakan air pada hidraulik hybrid direka bentuk dengan akumulator dan tanpa akumulator. Fasa reka bentuk boleh di kategori kepada 3 bahagian. Pertama, dengan menggunakan simulasi FluidSIm untuk menentukan aliran dan keperluan komponen. Kedua, mengubahsuai sistem air hidraulik mengikut aliran FluidSim. Akhir sekali, memasang pendawaian elektrik di dalam sistem untuk mengelakkan litar pintas. Selain itu, pelaksanaan sistem hidraulik air dianalisis dengan membandingkan kecekapan mekanikal, isipadu dan keseluruhan menggunakan akumulator atau tanpanya. Seterusnya, analisis pada sistem hidraulik air dengan meningkatkan tekanan pam untuk melaksanakan kehilangan tekanan dan kecekapan sistem.

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CO^2	*Carbon dioxide*
HHV	*hydraulic hybrid vehicle*
HEV	*hybrid electric vehicle*
DCV	*directional control valve*
PSM	*Projek sarjana muda*
EDM	*Electrical discharge machine*
MCB	*Miniature circuit breaker*
RCCB	*Residual current circuit breaker*
MIG	*Metal inert gas*

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Almost all people agree to renewable energy. This is because our earth, having an environment change climate due the impact usage of petroleum based gives several negative effects to the surrounding. Basically oil or crude oil from petroleum based had toxicity that can affect environmental neither human. Total oil consumption is much larger than consumption of hydraulic oil in this world. There has been a better interest in alternative Powertrain plans because the demand for more fuel efficient and emit carbon dioxide (CO^2) reduction. Among them, Hydraulic Hybrid Vehicle (HHV) technology is considered as a competitive alternative to the more conventional Hybrid Electric Vehicle (HEV) technology as already found on roads today (Toyota Prius, Lexus RX-400H, etc.). In general, a vehicle is considered as hybrid when it has more than one power source. This means that in addition to its primary energy source (most of the time the chemical energy of the fuel), the vehicle is also equipped with an additional energy storage system (Jefferson C.M and barnard R.H. 2002). In an HHV, the additional storage consists of pressurized oil or water. The hydraulic circuit is composed of a low pressure reservoir, a

high pressure accumulator and a reversible hydraulic machine operating in two modes, motor and pump (Liège, Chevreuils, & Liège, 2007).

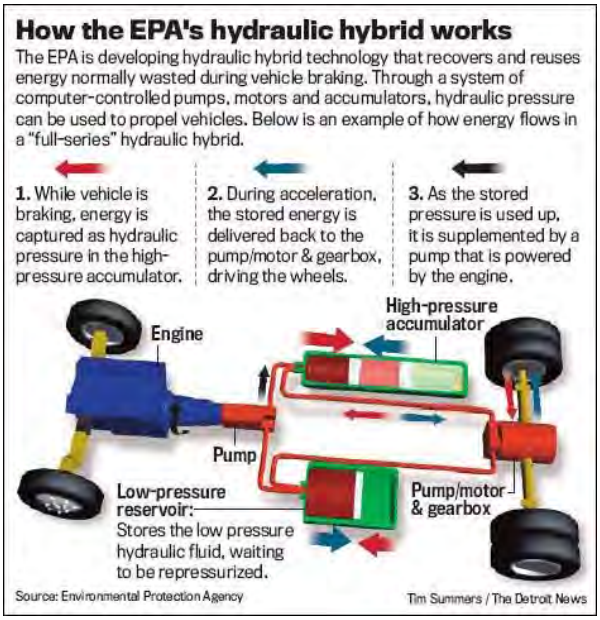

Figure 1.1 Basic Principle HHV (United States Environmental Protection Agency)

The basic principle of an HHV is shown in figure 1.1, whereby during braking phases, water or oil is pumped from the reservoir to the high pressure accumulator (the hydraulic machine is working as a pump). This stored energy is then used by emptying the accumulator through the hydraulic machine (working as a motor) when needed. By minimizing the amount of fluid power in a machine or a vehicle can shared signs of global climate work. Based on the use water hydraulic is one of the possibilities to improve fluid power more environmental friendly. This chapter will explain about objective, scope and problem statement about the water hydraulic hybrid project

1.2 OBJECTIVE

1. To design water hydraulic hybrid with accumulator and without accumulator
2. To analysis water hydraulic hybrid performance and efficiency.

1.3 SCOPE

1. Completion of water hydraulic hybrid circuit simulation using FluidSIM software.
2. Completion of modification circuit breaker and bypass to water hydraulic hybrid.
3. Testing and collecting raw data water hydraulic hybrid without accumulator.
4. Completion of testing water hydraulic hybrid performance with accumulator and without accumulator.

1.4 SIGNIFICANT STUDY

The water hydraulic system is equivalent to the normal hydraulic system. However the difference is medium inside the system to transmit the power. Currently trend hydraulic fluid power seems to move away from flammable oils. The obvious problems are an environmental problem, fluid disposal, safety and health can be deducted by using water hydraulic system. There have been actions to overcome the problem by introducing biodegradable synthetic oil. Still, it shows lower performance, poor lubrication and compatibility problem. The property of water is a factor in the comeback as the pressure medium. It has clean, safe and easy available properties sources. Besides that, water is eco-friendly, safe for life, no need to treat and dispose.

Currently hydraulic systems have been used widely in automotive, power plant, industries and etc. At this time in automotive industries, they keep on research on how making vehicle fully friendly usage. There are 2 most common hybrid, which are hybrid electric vehicles (HEV) and hydraulic hybrid vehicles (HHV). HEV uses two or more power sources to move the vehicle. Normally HEV, combines internal combustion and electrical motor as a mechanism to move the vehicle. Differ for HHVs; it uses two sources of power the vehicle that is pressure hydraulic fluid instead electrical motor and internal combustion engine. HHV is better than HEV in order to reduce the consumption of fuel, these technologies had to assist by accumulator and hydraulic drive motor. The motor helps the engine to accelerate the vehicle by reuse the energy breaking momentum. This will be more efficient to engine at starting point.

1.5 PROBLEM STATEMENT

The problem with common hydraulic hybrid vehicles is that it used petroleum based liquid or fluid. Petroleum product and mineral oil consist own composition that can cause a fire hazard. The usage petroleum-based fluid inside the vehicle may cause ablaze to the user if there are any leakage and oil spills that might trigger a fire accident. In order to distress this problem, water-based hydraulic system or water hydraulic was suggesting. Besides that, petroleum-based fluid may be a reason to environment issues. To rug, it need carefully taken care of. Otherwise, it will be dangerous to the environment. Moreover, medical and food industries usage oil in the production line such as pressing machine is not encouraging. This is because the safety of the product. It could be harmful to consumers if there is oil leakage and the oil include in the product. Based on the above problem, the situation can counter by change the medium transport form oil to water.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will show about fluid power concept in power transmission. There are 3 types of power transmission, which is mechanical, electrical and fluid power. Hydraulic and pneumatic are part of fluid power. Usually hydraulic liquid such as oil or water based and for pneumatic is for gas like air. That is a transport medium for the fluid system in order to transmit power. Then, there are 6 basic components of hydraulic system which is important to deliver power from sources to the output. Besides that, this chapter also reviews all journals, article, books and internet.

2.2 LITERATURE REVIEW

2.2.1 OVERVIEW HYDRAULIC FLUID POWER

Fluid power is technology that deals with generation, control and transmission of power using pressurized fluids. Basically, fluid power is important in moving the industry. All the machines of modern industry use fluid power to push, pull, regulate or

drive mechanical component to do the work. Fluid power is called hydraulic when the fluid is a liquid and is called pneumatics when called the fluid is a gas. Hydraulic usually use petroleum oil, synthetic oil and water. Water was used as the first liquid in a hydraulic system because it is readily available. However, water has many deficiencies in comparison to hydraulic oil. Water characteristic tends freezes more readily, is not good lubricant and the chance in rusting the metal component is higher than oil. In spite of these deficiencies, there is an improved effort to return to water applications because of water is abundant, no flammability and environmental cleanliness. To use water hydraulic, additive was added in water in order to prevent freezing, rust protection and improved lubricates. There are two types of fluid system. Those are fluid transport and fluid power. Fluid transport systems deliver fluid from one location to another to accomplish a beneficial purpose. Example include pumping station for pumping water to homes, across pipes or gas line and a system where chemical processing takes place as various fluids are brought together. Fluid power system is designed precisely to perform work. The work is done by pressuring the fluid bearing directly on a cylinder or fluid motor. Resulting forces develop inside linear motion for cylinder and torque in rotary motion for fluid motor. Sometimes, fluid cylinder and fluid motor are called actuator. There are many applications regarding fluid power, such as a hydraulic chain saw, excavator and pneumatic chain hoist.

The basic component in fluid power

1. Tank (reservoir) to hold hydraulic water.
2. Pump to force the water through the system
3. Electrical motor sources to drive the pump
4. Valve to control oil direction, pressure and flow rate.
5. Piping which carries the water from one location to another
6. Actuator is to convert the pressure of the water into mechanical force or torque to do useful work. An actuator can be dividing into two categories either cylinder to provide linear motion or motor (hydraulic) to provide rotary motion.

2.2.2 FLUID POWER COMPONENTS

2.2.2.1 PUMP

The pump is the heart of hydraulic system, convert mechanical energy to hydraulic energy. A source of mechanical energy is from prime mover such as electric motors. Due to mechanical action, the irrigation fluid inside pump change low pressure to higher pressure. The pump creates a partial vacuum as its inlet. This allows atmospheric pressure to push the fluid through the inlet and into the pump, then goes into the system. A pump may be classified as rotary, reciprocating or centrifugal. Rotary pump use gears, lobes, screw and vanes to trap and convey the fluid from the inlet to the system. Reciprocating pumps use back and forth motion of mechanical parts such as piston or a diagram to pressurize the fluid. To increase the kinetic and pressure of fluid using one or more rotating elements such as impellers as centrifugal force also known as centrifugal pumps. For this research, the piston pump triplex is used to operate water hydraulic system. The operation same as reciprocating pump which is the movement of a piston inside the cylinder.

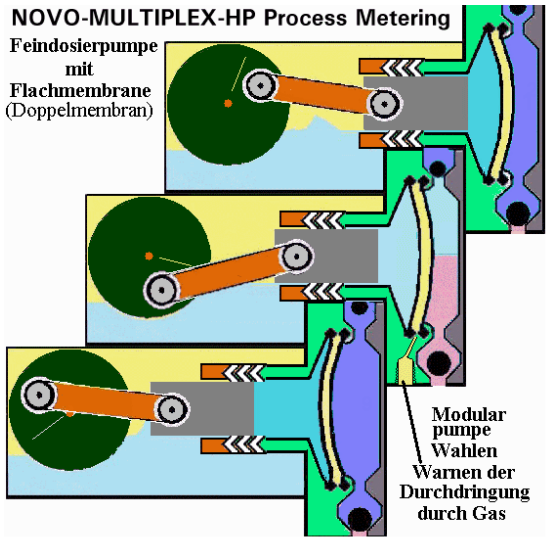

Figure 2.1 Reciprocating triplex pump (Sources: Pulseguard Ltd.)

Based on figure 2.1 above, when the piston moves in one direction, the water ahead of the piston is forced out of the cylinder. At the same time additional water is drawn into the cylinder behind the piston. Regardless of the direction of the movement of the piston, water is forced out of one end drawn into the other of the cylinder. Advantages using a triplex pump rather than simplex and duplex pump are the fluid deliver at high pressure, the flow far smoother and the peak flow more stable. However, the cost producing piston pump is high and the fitting clearances must be closed to avoid problem (connectinginindustri, 2014). Capacity of pump can be calculate according equation 2.1 (Digby, 2007).

$$Q(gpm) = Nc\frac{\eta d^2 ln}{924} \tag{2.1}$$

Where Q = capacity of pump, gpm

c = one-slip allowance; varies from 0.95 to 0.97

d = diameter of cylinder, in

l = length of stroke, in

n = number of strokes per min

N = number of cylinders in a pump

2.2.2.2 HYDRAULIC VALVE

Hydraulic valve is an important component inside hydraulic system. It controls different operation inside hydraulic system. If the control components are not properly selected, the entire system will not function as required. The selection of these valves involves not only the type, but also the size, actuating technique and remote control capability. There are 3 basic types of valve, first directional control valve, second pressure control valve and lastly is a flow control valve. Directional control valve decides the path through which a fluid transfers a given circuit. Commonly, the fluid path is complete by check valve, shuttle valve and two, three, four-ways directional control valve. Next, pressure control valve protects the system against overpressure, which may

occur due to excessive actuator load or due closing of a valve. In the general pressure control valve is archived by pressure relief valve, pressure reducing, sequence, and counterbalance valve. Therefore, flow in the hydraulic system must be controlled. For example, the actuator speed depends on the medium flow rates. This type of control is accomplished through the use of flow control valves. There are many valves to fulfil the system requirement of hydraulic, all symbol show at appendix A.

2.2.2.3 HYDRAULIC HOSE AND INSTALLATION COUPLING ROUTING

Hydraulic hose is a piping component that carries high pressure fluid within a hydraulic system. Mainly, hydraulic hose is made with three basic layer parts to increase their functionality, lifespan and endurance. The first layer is constructed by synthetic rubber tube such as Teflon, polyester-elastomer or neoprene that carries the fluid. The elastomer nature of rubber requires that a reinforcement layer be wound or braided around the tube in order to hold internal pressure. Then, the second layer is consisting of one or more layer depend on the pressure and the top outer layer to protect the hose from becoming cut or torn when contacting with other part. The methods in selection hydraulic hose with consider same condition that determines as follows (Gates Corporation, 2012).

1. The fluid should not exceed the maximum working temperature foe each recommend hose.
2. The working pressure hydraulic hose should be higher than the maximum operating pressure system.
3. To avoid obstructions in the hydraulic system and failure of the loss, the typical hose must be compatible with type of fluid.
4. To increase the lifespan of hydraulic hose, the installation bending radius should be minimum.

5. The hose and fitting should be compatible with the environmental factor such as temperature, fire hazard, electrical charge and others.
6. The dimension of all components is kept at minimum pressure to avoid overheating and turbulence.

Coupling Installation and correct routing is also an important to increase duration and to avoid failure. Thus, it need to be suitable and secure to elude leaking and injured happen. Some common injuries related to hydraulic hose are electrical shock, whipping hoses and fluid injection that can cause severe tissue hazard. The recommendation installation coupling and correct routing of each hose is show in figure 2.2.

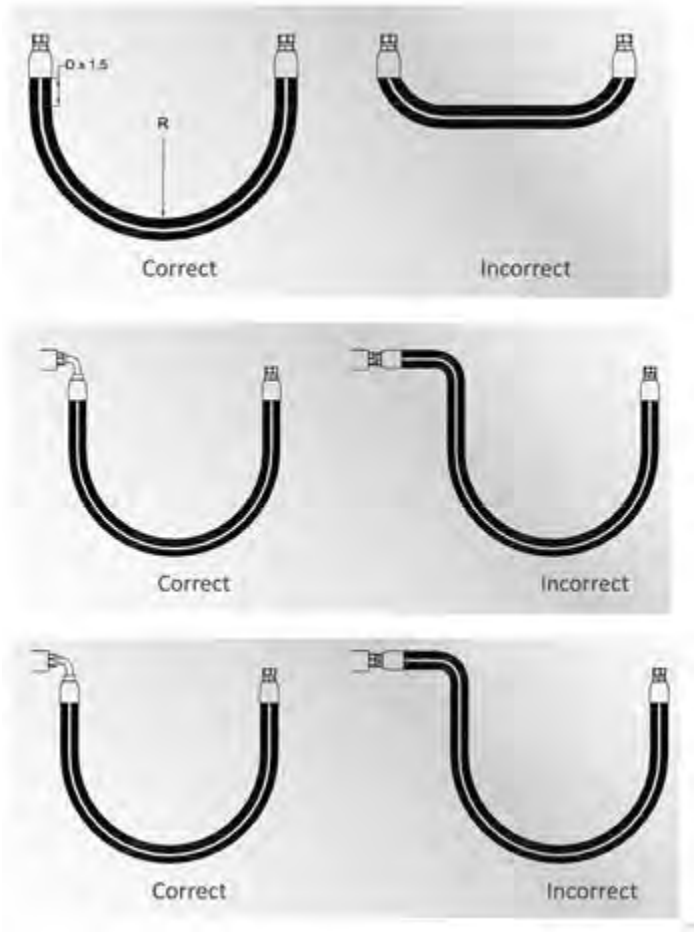

Figure 2.2 Recommendation coupling routing (Moreiras Luis, n.d.)

2.2.2.4 HYDRAULIC MOTOR

Hydraulic motor extract from fluid and convert it to mechanical energy to perform useful work. Hydraulic can be divided into limited rotation and continuous rotation type. A limited rotation also knows as rotary actuator or an oscillating motor. It simply rotates clockwise and anticlockwise, but through less than complete revolution. A continuous rotation hydraulic motor rotates continuously at an RPM that is determined by the motor input flow rate. That type of rotation also knows as hydraulic motor. The vane is type actuators are capable of many uses, such as closing and opening large plug-type valves and the like, or performing other services, particularly where push-pull or reciprocates movements are involved. Such actuators usually embody a housing having an accurate chamber in which a piston in the form of a vane attached to a drive shaft is impelled to and fro by pressure of fluid admitted at one side or the other of the piston or vane, with a concurrent exhaust of fluid at the opposite side thereof. Accordingly, the drive shaft may have limited rotation in either of two directions, depending upon which side of the piston is exposed to a thrust of fluid under pressure (Dejager, 1942). Hydraulic motor performance is evaluated on the same there efficiency that are mechanical, volumetric and overall efficiency).

$$\eta_v = \frac{Q_T}{Q_A} \tag{2.2}$$

Where $\eta_v$is volumetric efficiency, Q_T is the theoretical flow rate motor should consume for hydraulic motor and for pump is theoretical flow rate pump should produce in m^3/s, Q_A is the actual flow rate consumed by motor and for pump is actual flow rate produce by pump in m^3/s.

Equation 2.2 state that volumetric efficiency η_v is the inverse if for a pump, whereas a motor uses more flow than it should theoretical due to leakage (Anthony Esposito,2009). Then, equations 2.3 till 2.6 show mechanical efficiency η_m for hydraulic motor and inverse it for torque a pump. This is because due to friction, a pump required a greater torque than motor produce less torque.

$$\eta_m = \frac{T_A}{T_T} \tag{2.3}$$

$$T_T = \frac{V_D \times \mathcal{P}}{2\pi} \tag{2.4}$$

$$T_A = \frac{P}{N\left(\frac{rad}{s}\right)} \tag{2.5}$$

$$N\left(\frac{rad}{s}\right) = \frac{2\pi}{60} N(rpm) \tag{2.6}$$

Where η_m is mechanical efficiency, T_A is actual torque deliver by motor and for pump is actual torque delivered to pump in N.m, T_T is torque motor should theoretical deliver also theoretical torque to operate pump in N.m, V_D volmetric displacement in m^3/rev, $\mathcal{P}$ is pressure deliver in Pa, P is actual watt delivered by motor in watt and N is rotation of motor in rad/s or rpm.

Last, overall efficiency motor η_o is equal the product of the volumetric and mechanical efficiency according equation 2.7 and equation 2.8.

$$\eta_o = \eta_v \eta_m \tag{2.7}$$

$$\eta_o = \frac{T_A(N.m) \times N\left(\frac{rad}{s}\right)}{\mathcal{P}(Pa) \times Q_A\left(\frac{m^3}{s}\right)} \tag{2.8}$$

2.2.3 CHALLENGES OF WATER HYDRAULICS

Usage of water instead oil that act as a medium in a hydraulic system, increases problems with cavitation because water has a much higher vapour pressure (about 7.7 in Hg abs versus 0.1 in Hg abs at 150°F). Example, water has much greater tendency to