"I admit that I have read this report and I found that it is suffice from the aspect of scope and quality to pass the
Bachelor Degree of Mechanical Engineering (Thermal-Fluid)"

Signature : .....

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Date : 16-12-2005

APPLICATION OF HYDRAULIC TRANSMISSION FOR PROPULSION OF FORKLIFT

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This report is hand over to Mechanical Engineering Faculty as a requirement to pass a Bachelor Degree of Mechanical Engineering (Thermal-Fluid).

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NOVEMBER 2005

ADMISSION

" I admit this report is done all by myself except statement that I have already stated on each one of them"

Signature :.....

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Date :15 Dec 2015

This work is dedicated to my beloved mother, father and 2 of my younger brothers. You all are the best...

To all my classmates, do remember our friendships. It was a happy moment to be with you guys in these past few years...

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First of all in the name of Allah, thanks because give me brightness in darkness to completed this *Projek Sarjana Muda* (PSM) and report successfully. There is no regret when go through a thorny road with the guide from The Most Merciful.

In this opportunity, I would like to express my sincere gratitude to my supervisor Mr Kothwal Abdul Raheem for his invaluable guidance, indispensable help and continuous encouragement throughout the course and the success of this project.

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Finally, to my family, they gave me all the courage, inspiration, motivation, financial aid and love I need in my quest for the success and accomplishment for this project.

ABSTRACT

Power transmission using fluid power is one of method used commonly for industries field and vehicle. This " Projek Sarjana Muda" is performed to create one hydraulic transmission for propulsion of forklift base on Yale YDP 16AF. This project concerned activities such as study the scope provided and make an analysis and finding the result. By applying hydraulic transmission system this system more efficiency and capability carry large load but even pull forward large load added as additional achievement for these forklift compare with initial combustion engine for propulsion of forklift.

These activities contains study of hydraulic system, study of forklift, designing the hydraulic system, study of specification of hydraulic component related, whereas each formula emerged as performance formu8la and parameter that to make realization of this project and few a efficiency variable are not considered

All of design concept that will be done base on result provided through theory analysis, and to implement hydraulic transmission for propulsion of forklift, I hope this project will be continue by other student or industrial who are interesting about this project with hoping this project will be apply in real existence.

ABSTRAK

Penghanataran kuasa melalui kuasa bendalir adalah salah satu kaedah yang kebiasaanya digunakan di industri dan kenderaan. Projek Sarjana Muda ini adalah merekacipta satu sistem penghantaran kuada bagi jentera forklif Yale YDP 16AF dimana akitiviti-akitiviti kajian, analisis dan pnenemuan keputusan adalah bahawa penggunaan kuasa bendalir adalah lebih cekap dan mampu menampung beban yang lebih besar malah mampu menarik beban besar sebagai prestasi tambahan bagi forklift berbanding dengan menggunakan enjin pembakaran dalam bagi mengerakkan forklift.

Aktiviti-aktiviti projek merangkumi kajian terhadap sistem hidraulik , kajian terhadap forklift, merekacipta system hidraulik , kajian terhadap spesifikasi komponen hidraulik yang terlibat, dimana setiap formula yang terlibat sebagai parameter dan persembahan formula yang terbit bagi merialisasikan projek ini adalah berdasarkan teori dan beberapa nilai kecekapan tidak diambil kira.

Segala konsep rekacipta yang dilakukan adalah berdasarkan keputusan melalui analisis teori dan bagi merialisasikan system hidralik sebagai sistem penghantaran kuasa untuk menggerakkan forklift diharap projek ini dapat disambug pleh pelajar laini atau pihak industri sendiri sehingga ianya berjaya ditampilkan dalam bentuk yang nyata.

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CHAPTER 1

1.0 INTRODUCTION

As the title on this thesis, This project to share how capability of fluid power especially hydraulic transmission work compare with other transmission in common industry. But this thesis is specified applying fluid power in propulsion mobile, forklift.

Fluid power research and development has been extremely active to use as one of three commonly methodology of transmitting power in an industrial setting; the others are electrical and mechanical power transmission: Electrical power transmission uses an electric current flowing through a wire to transmit power. Its main advantage is its ability to transmit power over large distances very quickly. The most obvious example is the use of electricity to transmit power from the power plant to our homes. Mechanical power transmission uses gears, pulley, chains, and other such devices to transmit power over short distances with a large degree of rigidity. A simple example is the use of chain on a bicycle to transmit power from the pedals to the rear wheel. It is not uncommon to find all three forms of power transmission on a single machine. So, I will present this thesis is how ability the advantages of fluid power with the result of this thesis that's using the fluid power transmission.

There are actually two areas divided of fluid power: hydraulics and pneumatics. Hydraulic is the transmission of power through a liquid, most commonly based on oil. Pneumatic is the use of a gas. Refer to this project, it is hydraulic system field will be applied. Actually, this thesis suggests hydraulic system as transmission for propulsion of forklift because there are ability of high power and large load capacity of forklift required not by pneumatic system causes.

The applications of hydraulic system are actually two types used in industry: fluid transfer and fluid power. The purpose of fluid transfer system is to simply move a fluid from one location to another and fluid power systems have as their objective the transmission of power. They move large loads, which creates large resistances, and therefore must be capable of withstanding high pressures.

1.1 PROJECT BACKGROUND

The title of this thesis is "Application of Hydraulic Transmission for Propulsion of Forklift" concerned primary of the fluid power industries as original equipment manufacturing (OEMs) to create one new invention based on the discussion, objective, concepts, scope and problem solution to will be applied to achieve the expected result of how possible hydraulic transmission applying propulsion of forklift as well. These items from the component manufacturers will be useful in appropriate environment especially vehicle to do work such as lifting, carrying and pulling whereas possible in construction field and indoor like a industries area.

In America, The Fluid Power Society (FPS), whose complete formal name is The International Organization for Fluid Power and Motion Control Professionals, is a technical, professional organization devoted exclusively to the promotion and advancement of fluid power and motion control technology. As a professional association for the fluid motion industry, FPS'services includes membership, education, and certification. As of spring 1998, the FPS had a total membership of 2,500 individuals[1].

Refer text above we can see how the hydraulic research and development has been extremely active to use as one of the useful technology.

The forklift market is dominated by standard-electrical and combustion engine generate transmissions. The efficiency of standard transmissions is so high that there has not been much interest in exploring even greater efficiencies using other types of transmissions. One such option to the standard transmission is the hydraulic transmission. Off-road earth-moving equipment and similar applications have used hydraulic transmissions (hydrostatics) for years. Hydrostatics for propulsion of forklift vehicles has not been considered feasible because hydrostatics are less efficient than standard transmissions and better suited to low-speed, high-torque applications, not to high-speed forklift use.

I would like to roughly explain that the main scope of this thesis is forklifts are used to make a conversion of their combustion engine as mechanical transmission already to hydraulic transmission whereas two main reason why its be selected; forklift use hydraulic transmission already in other system, and forklifts are used to work on high load required such as engage, lift, and transfer palletized loads in warehousing, manufacturing, materials handling, and construction applications. Here hydraulic power transmission useful to take the application required.

1.2 OBJECTIVE

Archiving how the capability of hydraulic transmission while applying to moving wheel of forklift where they are hydraulic power transmission already build for other purpose whereas applying in lifting system, brake system and steering system.

Refer on subchapter Introduction on this thesis, the hydraulic transmission will be exchange from combustion engine as mechanical transmission whereas the forklift work will be capability to do work required large load of capacity.

Improving the forklift transmission is another important of the study where as the advantage theoretical applying hydraulic transmission in propulsion of forklift will be done fluid power systems provides multiplication and variation of force; rotary force can be multiplied from a fraction of an ounce to pull of carry high load capacity of forklift as output.

This project like many company's latest developments have already taken mobile equipment into a new realm of sophisticated technology.

1.3 STUDIES SCOPE

1) Studying of hydraulic transmission concept
2) Specification of hydraulic component
3) Hydraulic system design
4) Studying of forklift system (Battery forklift: Caterpillar EP16K, Diesel forklift: Yale GD4 16K)
5) Studying simulation software (automation studio)
6) Consider the all calculation related
7) Show the theoretical related

1.4 PROBLEM STATEMENT

1) There are forklift using mechanical transmission whereas wheel rotation generated by two sources commonly that is battery and combustion engine. Carrying higher load just make the engine might be damage cause of over heat when forcing work.

2) Industrial are not to forcing forklift to do work with low specification and its small to carrying or pull large load over their load capacity capability. So, it is required to provide other high specification and size of forklift to carrying higher load where there is high cost purchase.

3) By upgrade the system with mechanical device complicated just providing its position problem to stall where they are high renovation required.

1.5 ANALYSIS PROBLEM

1) Hydraulic actuators can be stalled without damage while combustion engine generate the energy to produce torque of wheel of forklift will over heat. This makes fluid power the choice for applications to solve the problem.

2) Improve the transmission of combustion engine forklift by added the hydraulic transmission as conversion from combustion engine as initially source to rotate the wheel, the power is transferred through flexible hoses. This reduces the number of components in a machine, resulting in fewer service complications. It also allows delivering power to places where it would be impossible to run a drive shaft or chain drive. Freed from having to arrange a linear sequence of mechanical drivelines, equipment designers are creating more compact and better balanced machines with better service access points and larger operator stations.

3) Hydraulic systems are preferred for apply to forklift pull the high load. In fact, hydraulic motors can usually generate enough force to direct drive the propulsion.

4) Conclusion of this problem statement is when forklift work to pulling high load levels are needed, hydraulics is cost effective compare while electric motor added or convert high power combustion engine in forklift.

1.6 EXPECTED RESULT

The conceptual of hydraulic system that will be designed for propulsion of forklift is a reflection of this thesis commitment to producing products of only the highest value. Featuring the most advanced hydraulic component technology available in the industry, these lift trucks provide work pulling the high load that more than common forklift work lifting and carrying the load.

At the outset of the project, a roughly thorough analysis of the entire system will be done, from the diesel engine that drives the wheels as actuation of the proportional. This unique system that be expected will be do were not considered the most cost-effective way of tackling these problems. Instead the decision was made to design a brand new transmission system with an altered hydraulic system. I have set to work and came up with something unique

This project simply to make the forklift will be useful as multi purpose forklift and might be potential to use in construction field and indoor like industries are as well. The forklift provide to pull and carrying high load from one position to other position.

This project with small cost compare by buying the higher specification and size forklift to carrying higher load fulfill the function of working to pull and carry high load. While reducing the cost, this project will also consider upgrade the small forklift already.

By the end of this project the machine should achieve main objective that is to achieve how the benefit of hydraulic transmission while combined with hydraulic system already that purpose applying other subsystem such as break system, lifting system, and steering system refer forklift with new hydraulic system will be designed for propulsion applying to moving wheel of forklift.

1.7 LIMITATION OF STUDIES

Activities of this project are more to study how possible application hydraulic transmission for propulsion of forklift. That all due basic principle of fluid power, background hydraulic transmission for vehicle propulsion, and forklift specification including their hydraulic system already. The methodology of this project are base on show the diesel forklift refer YALE GDP 16 AF forklift, new concept design, hydraulic transmission system for forklift, motor circuit diagram parameter related and performance formula to sizing the equipment.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 FLUID POWER

As I have roughly explain the definition of fluid power on sub chapter Introduction, Fluid power is energy transmitted and controlled by means of a pressurized fluid, either liquid or gas. The term fluid power applies to both hydraulics and pneumatics. Hydraulics uses pressurized liquid, for example, oil or water; pneumatics uses compressed air or other neutral gases. Fluid power can be effectively combined with other technologies through the use of sensors, transducers and microprocessors.

Before we are going through the hydraulic transmission, the basic principle about how fluid power works required understanding when applying to propulsion of forklift whereas there are might be more complicated.

How Fluid Power Works

Pascal's law states that when there is an increase in pressure at any point in a confined fluid, there is an equal increase at every other point in the container. [2]

A container, as shown below, contains a fluid. There is an increase in pressure as the length of the column of liquid increases, due to the increased mass of the fluid above.

Blaise Pascal 1623 - 1662

Pascal's Law expresses the central concept of fluid power: "Pressure exerted by a confined fluid acts undiminished equally in all directions."

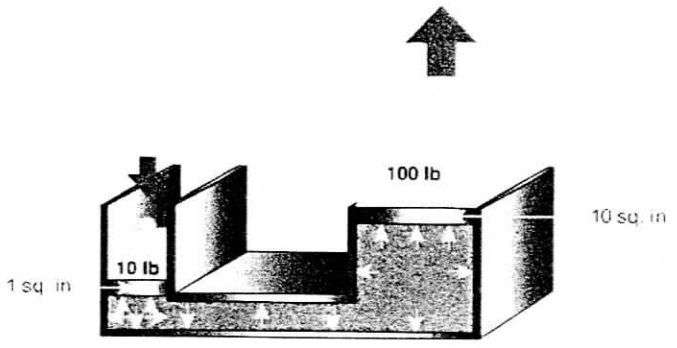

Figure 1: Basic Principle of Pascal's Law

Description:

An input force of 10 pounds (44.8 N) on a 1-square-inch (6.45 cm2) piston develops a pressure of 10 pounds per square inch (psi) (68.95 kN/m2 or 68.95 KPa) throughout the container. This pressure will allow a 10-square-inch piston to support a 100-pound (444.8 N) weight. The forces are proportional to the piston areas.

2.2 HYDRAULIC SYSTEM

Hydraulic systems use an incompressible fluid, such as oil or water, to transmit forces from one location to another within the fluid. Most aircraft use hydraulics in the braking systems and landing gear. Pneumatic systems use compressible fluid, such as air, in their operation. Some aircraft utilize pneumatic systems for their brakes, landing gear and movement of flaps.

The block diagram shown in **figure2** illustrates a basic hydraulic system. A typical system has these five components:

1) Power input device – this is the pump that provides hydraulic power to the system.
2) Control devices – to control direction, pressure and flow rate of the pressurized liquid in our hydraulic system, valves are used.
3) Power output device – this is where the hydraulic power converted back to mechanical power. These devices are called actuators. The hydraulic motor shown in **figure 2** is an example of an actuator. Another actuator is the cylinder.
4) Conductors – to transmit the liquid, conductors (pipes, tubes, of hoses) are needed.
5) Liquid – this is our power conducting medium. Typically this is oil but other liquids are used in special circumstances.

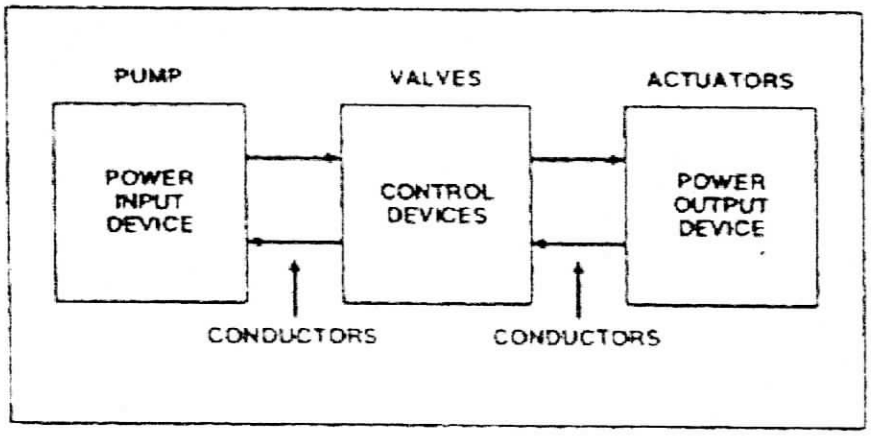

Figure 2: Hydraulic System Block Diagram

2.3 HYDRAULIC TRANSMISSION AND COMPARISON WITH MECHANICAL TRANSMISSION

2.3.1 Hydraulic Transmission

Hydraulic transmission or other name called hydrostatic transmission concerned device employing a liquid to transmit and modify linear or rotary motion and linear or turning force (torque). The hydraulic torque converter, which use the kinetic energy of the liquid; and hydrostatic, which use the pressure energy of the liquid. There is no mechanical coupling of the input and output. Hydraulic systems are widely used in many industrial applications. Over half of all industrial products have fluid power systems or components as a part of their basic designs. The creative aspect of hydraulic system design is to develop a circuit that is capable of performing the required task. Usually the basic functions of a hydraulic system are determined by the circuit configuration, while the circuit's performance mainly relies on the components' sizes and characteristics.

2.3.2 Mechanical Transmissions

A mechanical transmission is an intermediary device for transmitting the rotary energy of the vehicle engine at a suitable rotation speed, to the differential and from there to the driving wheels.

The need for a transmission in an automobile is a consequence of the characteristics of the internal combustion engine. Engines typically operate over a range of 600 to about 6000 revolutions per minute (though this varies from design to design), while the vehicle wheels rotate between 0 rpm and around 2500 rpm. Furthermore, the engine provides its highest torque outputs approximately in the middle of its range, while often the greatest torque is required when the vehicle is moving from rest or travelling slowly. Therefore, a system that transforms the engine's output so that it can

supply high torque at low speeds, but also operate at highway speeds with the motor still operating within its limits, is required. Transmissions perform this transformation.

Most transmissions and gear boxes used in automotive and mobile applications are contained in a cast iron case, though sometimes aluminum is used for lower weight. There are three shafts: a mainshaft, a countershaft, and an idler shaft.

The main shaft extends outside the case in both directions: the input shaft towards the engine, and the output shaft towards the rear axle. The shaft is suspended by the main bearings, and is split towards the input end. At the point of the split, the pilot bearing holds the shafts together. The gears and clutches ride on the mainshaft, the gears being free to turn relative to the mainshaft except when engaged by the clutches.

The countershaft is generally below the mainshaft and turns in the opposite direction, driven by a bevel gear on the input shaft.

2.3.3 Hydrostatic Transmission Offers over Traditional Mechanical Transmission[3]

Six advantages a hydrostatic transmission offers over a traditional mechanical transmission:-

- High power density (high power output per unit mass)
- Infinitely variable and step-less speed (and torque) control – both forward and reverse
- Up to 90 percent of maximum torque available at start-up or break-out
- Low inertia of rotating parts permits rapid starting, stopping and reversing
- Simple overload protection

• In the case of forklift drives, the engine can be located anywhere in the machine without the need to consider complicated driveshaft and drive axle arrangements.

2.3.4 Criteria of Hydrostatic Transmission

Hydrostatic transmissions can have below:-

A variable displacement pump and a fixed displacement motor

Can vary the speed, but the torque output at a given pressure is fixed because this depends on the motor displacement. This is called a constant torque drive.

A fixed displacement pump and variable displacement motor

Motor can control both speed and torque, because both depend on the motor displacement. With this system, however, speed and motor results in a speed decrease and torque increase by the same factor (at fixed pressure). This system is called a constant horsepower drive because the output horsepower remains fixed at a particular pressure.

Or both may be variable

The horsepower output with a variable displacement pump and a variable displacement motor allows the speed and torque to be varied independently, but is much more difficult to control.