

## **SUPERVISOR DECLARATION**

“I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant and Maintenance)”

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**INVESTIGATION OF HYDRAULIC PISTON DUE TO CONTAMINATION**

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**This thesis is submitted as  
partial fulfillment of the requirement for the award of a  
Bachelor of Mechanical Engineering (Plant & Maintenance) with Honours.**

**Faculty of Mechanical Engineering  
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## DECLARATION

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

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Date : .....

*'Dedicated to my loving mother, Natifah Binti Bakar  
and My loving father, Mutafa Bin Mahmud together  
with siblings, family, lecturers and friends.'*

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I am Mastura Binti Mutafa feeling grateful to Allah SWT for with His consent and bless that I have successfully done my thesis for Final Year Project 2. I am thankful to all my parents, my dad (Mutafa Bin Mahmud) and my mother (Natifah Binti Bakar) for their support and contribution in completing this project and during writing this report.

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## ABSTRACT

Hydraulic piston is a steel cylinder moving inside another steel cylinder and usually used to apply force mechanically in a straight line by pumping high pressure of liquid into the space between the two pushing the inner cylinder out. Oil uses for hydraulic piston to move the hydraulic piston. These types of oil must contain several characteristics such as, anti-wear and anti-corrosion because to prevent and avoid the failure on the hydraulic piston. From this study, there are many types of the hydraulic fluid will be known. Using the oil analyser of FluidScan Q1000, the types of contamination in the hydraulic fluid will be known faster than using others method to check the contamination in hydraulic fluid. This type of equipment usually uses to detect the contamination in the oil. The hydraulic piston major failure will be known for this type of oil analysis using Q1000. The purposes of using this new equipment are fast and accurate result will be determined and this equipment also needs less than a minute to test the oil. The oil is needed for the testing also less than using another method. There are some factors that will influence the hydraulic fluid that are uses contain the contaminant will explain further in this project. Explained in this paper are the features of the hydraulic fluid system and the rate of contamination of the environmental particle will affect the system. This method of determined the contamination will increase the life of hydraulic piston and also preventing the contamination entering the hydraulic piston.

## ABSTRAK

Ombok hidraulik silinder keluli bergerak di dalam satu lagi silinder keluli dan biasanya digunakan untuk daya keaan mekanikal dalam garis lurus untuk mengepam tekanan tinggi cecair ke dalam ruang dimana kedua-duanya menolak silinder dalaman keluar. Jenis minyak hidraulik mesti mengandungi beberapa ciri-ciri seperti, anti-haus dan anti-karat untuk mencegah dan mengelakkan kegagalan pada ombok hidraulik. Dari kajian ini, terdapat banyak jenis bendalir hidraulik yang akan diterangkan. Menggunakan penganalisis minyak daripada FluidScan Q1000, jenis-jenis pencemaran di dalam cecair hidraulik akan dapat diketahui dengan lebih cepat daripada menggunakan kaedah lain. Tujuan menggunakan peralatan baru ini adalah lebih cepat dan keputusan yang tepat akan ditentukan dan peralatan ini juga kurang daripada satu minit daripada masa menguji minyak. Terdapat beberapa faktor yang akan mempengaruhi bendalir hidraulik yang telah mengandungi bahan tercemar yang akan dijelaskan lebih lanjut dalam projek ini. SEperti yang dinyatakan dalam kertas kerja ini, terdapat ciri-ciri sistem bendalir hidraulik dan kadar pencemaran zarah alam sekitar yang turut memberi kesan kepada sistem. Kaedah ini, akan dapat meningkatkan kehidupan ombok hidraulik dan juga mencegah pencemaran yang akan berlaku pada ombok hidraulik.

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## CHAPTER 1

### INTRODUCTION

#### 1.0 OVERVIEW

This final year project 2 is about the investigation of hydraulic piston due contamination play its part of hydraulic piston and others type of contamination. There are three main purposes of the investigation is to identify the major cause of the hydraulic piston failure, to predict onset of failure using oil analysis equipment Q1000 and to measure the rate of contamination of environmental particles.

Hydraulic piston is a type of steel rod that is moving inside another steel cylinder and the applied force of the hydraulic piston is mechanically in a straight line. The force applied by pumping the high pressure into the blank space within the two inner cylinders out. The hydraulic piston engine uses the principle of a reciprocating plunger pump without other mechanical system and the sequence of the two inner cylinders out. Besides that, the energy from the combustion process of the fuel will convert directly to the energy of hydraulic through the rigid piston assembly and normally the crankshaft found in the conventional engines will be cancel. The piston assembly contain of the pump piston, rebound piston and the power piston that is rigidly connected to the piston rod not by the crankshaft. (Z. Zhao, Zhang, Huang, Zhao, & Guo, 2012).

In order to identify the conditions of hydraulic piston is due to contamination in every long period of time and several testing work will be conducted. This project also will identify the type of contamination occurs.

### **1.1 PROBLEM STATEMENT**

For military transport, especially tipper truck, driver and maintenance department and more focusing on using the tipper truck without care about the condition of hydraulic tipper and continue the service of the truck based on the schedule. Normally, drivers are aware that contamination is responsible for the major failure in hydraulic systems. However, knowing that dirt will destroy your hydraulic system does not translate directly into knowing what to do when that happen or how to prevent contamination from re-entering the system and causing another costly failure.

### **1.2 OBJECTIVE**

The following are the objectives of this final year project;

1. To predict onset of failure using oil analyser equipment
2. To identify the most critical types of contamination

### **1.3 SCOPE**

This scope of this project is divided into two, which is;

1. Industrial tipper
  - To observe failure of the tipper truck.
  - Collect the specimen (oil) in hydraulic piston.



## 2. Testing work

- The experiment will be conducted using the oil from the hydraulic piston.

## 1.4 STRUCTURE OF REPORT

These phases of the investigation of hydraulic piston due to contamination are structured as follows;

- **Chapter 2 (Literature Review)**

A literature review section that provides all the information regarding this project.

- **Chapter 3 (Methodology)**

Methodology part shows all the scientific and testing work used in this project.

- **Chapter 4 (Data and Results)**

The result of oil analysis and wear debris analysis, testing will be stated in chapter 4 as data and results.

- **Chapter 5 (Discussion)**

From the result of testing work in chapter 4 (Data and Result), discussing and analyzing the data would be done in this chapter5.

- **Chapter 6 (Conclusion and Recommendation)**

In this chapter 6, the conclusion of the findings would be concluded and several recommendations should be done for further this project.

## **CHAPTER 2**

### **LITERATURE REVIEW**

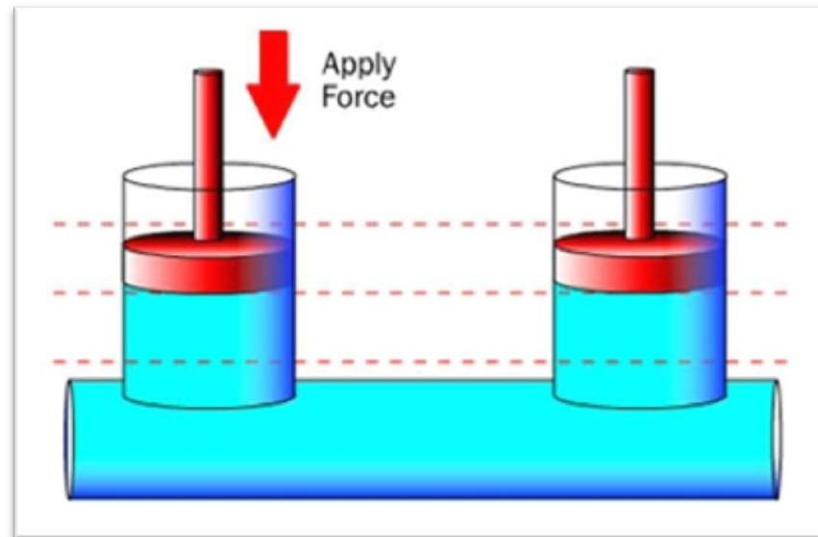
#### **2.0 INTRODUCTION OF LITERATURE REVIEW**

This chapter explains about the history of hydraulic piston including the principle of the hydraulic piston uses and the common process of oil analyses. The importance of using hydraulic piston and tipper as well as the causes that make the oil get the contamination will be explained in this chapter. Terms such as tipping, contamination, surface hardness, test rig, anti-wear and anti-corrosion are elaborate in this chapter.

#### **2.1 PRINCIPLE OF HYDRAULIC PISTON**

Hydraulic piston is using the principle of Pascal's law that stated as when there are increases in pressure at any point in a confined fluid, there is an equal increase at every point in the container. Incompressible fluid such as oil and water are used to transmit the force from one location to another in the hydraulic system. Incompressible fluid such as oil has the highest efficiency compared with water.

For example, understanding the principle of hydraulic piston, a simple hydraulic system was a design that consists of the two pistons and an oil- filled pipe connecting them.



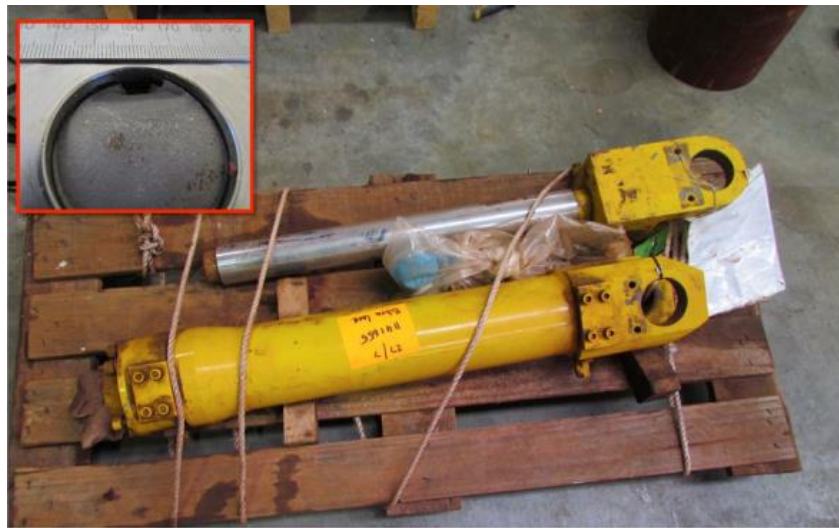
**Figure 2.1:** model of simple hydraulic system (sources: howstuffworks.com)

Based on figure 2.1, the model of simple hydraulic system is shown. The model of simple hydraulic system shows the two pistons in red fitted into two glass cylinder that fully filled with oil in blue colour and was connected through an oil-filled pipe. When the force was applied downward to one piston on the left, the force will transmit through the oil in the pipeline to the second piston in the right. It shows that the force was applied to the second piston is equal to the force at the first piston.

Newton, Pascal and Galileo discovered the interesting phenomenon of the actual practice practical applications and they come out with the formulae of the “Law of Hydraulics”. The Pascal’s law stated that hydraulic piston will function when the external force exerted on a unit of area of a confined liquid will transmit undiminished to every unit area of the interior of the vessel. (Hydraulic, n.d.)

### 2.1.1 Causes of failure

The actuator is the hydraulic cylinder in the hydraulic system and the failure will directly affect the normal operation of the system. Major failures in hydraulic systems are leakage that can cause of failure or damage of the seal and it should be detected to avoid worse breakdown of the system. Besides that, the leakage is difficult to be diagnosed in the early stage. (X. Zhao et al., 2015)



**Figure 2.2:** types of failure in hydraulic cylinder

(Source: materialsolutions.com)

There are several types of failure that can cause damage of hydraulic piston such as poor system design, using the low quality of liquid or poor contamination control. Based on the damage that will occur, several types of prevention can be conducted.

By using the low quality of hydraulic fluid, it can cause damage of hydraulic piston. The best way to prevent the damage is using the highest quality of hydraulic fluid and use high quality hydraulic fluid with the correct viscosity. Hydraulic fluid should also be kept cool, dry and clean. Oil analysis is the best to avoid failure in hydraulic piston due to contamination, with particle contamination making up the largest portion. The hydraulic cylinder is the most expensive component of a hydraulic system and has the highest reliability risk, the highest contamination sensitivity risk and the ability to cause a chain-reaction failure.

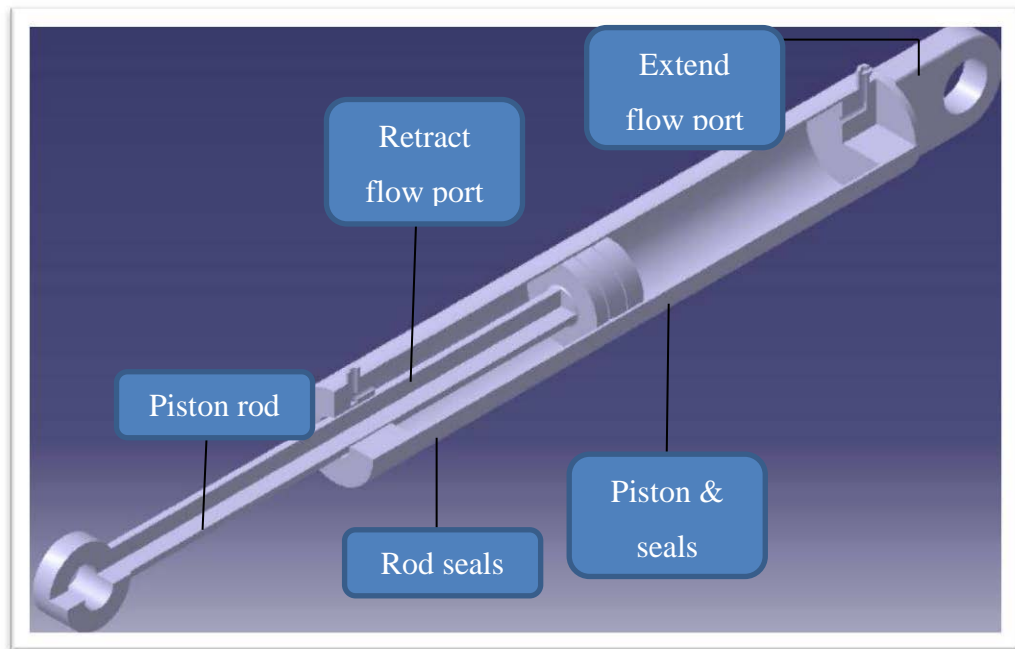
### 2.1.1 Uses of tipper in industries

The tipper trucks are used for transporting loose material such as sand, garbage, gravel or for construction. Normally, the truck is equipped with an open-box bed that hinged at the rear and equipped with hydraulic piston to lift the front. It will allow the material in the bed dumped on the ground behind the truck at the site of delivery. Nowadays, virtually all trucks operate by hydraulics and also come in a variety of configurations each designed to accomplish a specific task. The hydraulic system has become so importance in the industries, especially in the automotive industries.



**Figure 2.3:** Tipper truck (Source: diytrade.com)

## 2.2 COMPONENT DESIGN IN HYDRAULIC PISTON



**Figure 2.4:** hydraulic piston (Source: globalspec.com)

The main component in hydraulic piston:

**Piston rod** - normally piston rod have a high strength steel, ground, case-hardened, polished and hard chrome plated for reducing wear and corrosion resistance. The corrosive atmosphere conditions usually require the rods of stainless steel which is chrome plated for wear resistance.

**Rod seals** – rod seals are used for contributing to overall actuator friction and any external leakage because of the actuator friction is low, it assumes negligible. The scraper seals are installed in the external housing or at the piston rod interface.

**Piston and seal** – the scraper seals will help to clean frosted, ice or debris off of the piston rod. It will help to prevent damage to the pressure seals and also prevent the foreign particle from entering the actuator.

## 2.3 TYPES OF CONTAMINATIONS

Contamination is the presence of a minor and unwanted constituted, smallest particle in a material, physical body, natural environment and workplace. There are many types of contaminations such as oil, water, chemical, environment particles, pressure and temperature that can make troubleshooting of hydraulic system. Besides that, contamination can be occurs based on the premature rod seal failure.

### 2.3.1 Air

Air is the types of the fluid contamination, but aerated oil also can cause physical damage to the piston rod seal. The bubbles of air occur when the pressure shock in system with highly cycling speed to become charged with heat energy. That's conditions often refer to as "dieseling". Presence of air in fluid can cause transmission of vibration and it will form the system to load failure.



**Figure 2.5** Error! Unknown switch argument.: Contamination damage to the rod steel  
(Source: Wear, n.d.)

The figure 2.5 above shows the contamination damage of the rod seal. The two rod steel shows the difference between before contamination is the left and after contamination is the right. The contamination damage done because of the serrations are worn completely away. That condition shows a rod-up application where a rapid increase in hydraulic pressure can cause intense and localized heating of the bubbles at the lip of the primary seal. (Wear, n.d.)

### 2.3.2 Water

Especially in hydraulic, water contamination in hydrocarbon fluid may cause many problems. Free, emulsified and dissolved are the types of water that will form in oil. Free water known as the larger bodies of water in oil, and in static reservoirs to produce free water, the water is free to move to the bottom of the tank and separate from the oil. Besides that, emulsified water is the tiny droplet in oil and normally dispersed by high shear mixing. Dissolve is when the water is chemically absorbed in solution with the oil and the solubility is less than 150 parts per million (ppm) at ambient temperature when it dissolve in most hydrocarbons. But the solubility will increase slightly with temperature. (Schnable & Carp, n.d.)



**Figure 2.:** Example water contamination in oil (Source: biokem.com)

Figure 2.6 shows water contamination in the oil. It causes the corrosion occurs in the hydraulic system.

### 2.3.3 Chemical

Some of the chemical contamination will react with seal material and attack them chemically. Fluid manufacturers often list common seal materials as compatible without defining the suitability of material for the dynamic seal and it's also for the static seal material.