UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN ENHANCEMENT AND ANALYSIS OF LUBE OIL FILTRATION PROCESS FOR ENGINE LUBRICATION APPLICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology) with Honours

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Mechanical Engineering Technology) (Hons.). The member of the supervisory is as follow:

…….

(Mr AZRIN BIN AHMAD)

ABSTRACT

Filter is used to flush out contaminate from the used lube oil. Lube oil is commonly used to reduce friction and wear, reduce temperature, minimize corrosion, energy reduction and reduce shock in the industrial application especially in the engine system. Consequences from the long use of the lube oil, the lube oil will be deteriorate and it need to be filtered. The purpose of this project is to redesign the filter of used lube oil and analyse the properties of the used lube oil after the filtration process whether there is some improvement or not in terms of quality of the used lube oil and to avoid depletion of oil sources. To improve the current design of the filter, SolidWorks software is used to ease the redesign process. This software is used to develop a new design of filter before the fabrication process. After the filtration process done, the used oil will be filtered and analysed by using Rotating Disc Electrode Atomic Emission Spectrometry (RDE-AES), Pensky-Martens Flash Point Tester and Heated Viscometer. The used of all of these equipment was followed the ASTM D 445, ASTM D 6596 and ASTM 93. This kind of equipment is used to identify the type element content and the viscosity of the used lube oil after undergo the filtration process. By designing this lube oil filtration process, used lube oil can be used again and it can reduce the running cost with extending life cycle of all the system components inside the engine.

ABSTRAK

Penapis digunakan untuk mengasingkan bendasing daripada minyak pelincir yang digunakan. Minyak pelincir biasanya digunakan untuk mengurangkan geseran dan haus, mengurangkan suhu, mengurangkan hakisan, pengurangan tenaga dan mengurangkan kesan dalam terutama dalam sistem enjin. Akibat daripada penggunaan dalam tempoh yang lama minyak minyak pelincir, minyak pelincir akan merosot dan ia perlu ditapis. Tujuan projek ini adalah untuk mereka bentuk semula penapis minyak pelincir digunakan dan menganalisis sifat-sifat minyak pelincir yang digunakan selepas proses penapisan sama ada terdapat beberapa peningkatan atau tidak dari segi kualiti minyak pelincir yang digunakan dan untuk mengelakkan kekurangan sumber minyak. Untuk meningkatkan reka bentuk semasa penapis, perisian SolidWorks digunakan untuk memudahkan proses reka bentuk semula. Perisian ini digunakan untuk membangunkan reka bentuk baru penapis sebelum proses fabrikasi. Selepas proses penapisan yang dilakukan, minyak yang digunakan akan ditapis dan dianalisis dengan menggunakan berputar cakera elektrod menggunakan Rotating Disc Electrode Atomic Emission Spectrometry (RDE-AES), Pensky-Martens Flash Point Tester dan Heated Viscometer. Yang digunakan untuk semua peralatan ini diikuti ASTM D 445, ASTM D 6596 dan ASTM 93. Ini jenis peralatan yang digunakan untuk mengenal pasti kandungan unsur jenis dan kelikatan minyak pelincir yang digunakan selepas menjalani proses penapisan. Dengan mereka bentuk ini proses penapisan minyak pelincir, minyak pelincir boleh digunakan semula lagi dan ia boleh mengurangkan kos berjalan dengan memanjangkan kitaran hidup semua komponen sistem di dalam enjin.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminiums
Ag	-	Silver
B	-	Boron
Ba	-	Barium
C	-	Carbon
Ca	-	Calcium
Cd	-	Cadmium
CAD	-	Computer Aided Design
Ca2 – BaF2	-	Calcium Fluoride-Barium Fluoride Eutectic
Cr	-	Chromium
cSt	-	Centistokes
Cu	-	Copper
Fe	-	Iron
GAC	-	Granular Activated Carbon
H	-	Hydrogen
K	-	Potassium
Li	-	Lithium
Mg	-	Magnesium
Mn	-	Manganese
MoS2	-	Molybdenum Disulphide
Na	-	Sodium
Ni	-	Nickel
P	-	Phosphorus
PAC	-	Powder Activated Carbon
Pb	-	Lead
Ppm	-	Part per million
RDE-AES	-	Rotating Disc Electrode Atomic Emission Spectroscopy
SAE	-	Society of Automotive Engineer

Sb	-	Antimony
Si	-	Silicon
Sn	-	Tin
Ti	-	Titanium
USA	-	United States of America
UTeM	-	Universiti Teknikal Malaysia Melaka
QFD	-	Quality Function Deployment
V	-	Vanadium
Zn	-	Zinc

CHAPTER 1
INTRODUCTION

1.1 Background

Lubricant is an element that has been used to smooth the movement between two contact surfaces. Lubricant could be made from solid, semi-solid or liquid elements. The variation of elements in the lubricant makes it become multipurpose. In other words, it can be applied in any circumstances based on its properties.

The smoothness of the movement between two contact surfaces is due to the reduction of friction. Friction occurs when there are contact between two moving surfaces. Consequently, there is resistance force that occurs between the movements of the contact surface (Sahoo, 2009). The reduction of friction will ensure that there are no disturbance occur in the movement of the contact surface.

Lubricant's primary functions are to help overcome the friction (Bannister, 2007). Besides that, lubricant also can minimize corrosion by providing a lubricating film that acted as a barrier to prevent the surface from moisture in the air and others corrosive substances. Then, it also plays an important role to seal out contaminates by flush out contaminants away from the systems. Lastly, lubricant can reduce the energy usage.

The main function of the engine lubrication system is to maintain the efficiency operation of the engine system and maintain a positive and continuous oil supply to the bearing. In addition, the pressure of the engine oil should be high enough to cause the oil flow that is required for proper cooling. (Halderman &

Mitchell, 2005). So, it is important to keep and maintain the lubrication system of the engine.

Besides that, lube oil can prolong the lifespan of the moving parts that operate in engine system by different condition in terms of speed, temperature and pressure. At the early stage of the lube oil usage, there were no standardized usage and limitation of time or mileage that were used to maintain the effectiveness of the lube oil to lubricate all the components in the engine system. Due to that reason, lube oil need to be changed more frequently (Ahmed & Nassar, 2011).

During engine operation, there will be a contamination occurs and this will make the engine component damage. Wear debris, peroxides, acids, soot particles, or sludge may be the sources of the contaminants (Ahmed & Nassar, 2011). So, when the lube oil no longer can be used for protecting the component in the engine system and it becomes hazardous. It needs to be changed.

Once the lubricant is being replaced, the lubricant need to be disposed in a proper ways. It is a major management challenge in terms of the method of controlling the disposal of the used lube oil. If not disposed properly, it can dangerous the ecosystem and environment. It can lead to the health problem. Many countries in the world admitted that the problem of the environmental problem is caused by the waste or used lubricating oil (Cooke, 1982). For example, about 2 billion gallons of oils are produced each year in the USA (Coyler, 2000).

This shows that, without a proper planning and management in handling the lubricating oil. It will make a disaster to the earth. So, one of the ways in order to keep the used lube oil from being dumped is to recycle it. The initiative is to design a new filter that can filtrate all the contaminant from the used lube oil. Due to the lube oil filter, all the contaminant in the lube oil and all cost in order to maintain the component in the engine system can be reduce.

The recycle process of the used lube oil started when the used lube oil will undergo a filtration process to clean out all the contaminants. This process will make the used lube oil become reusable. In order to remove all the contaminants, the used lube oil needs to be filtered by surface filter and depth filter. The process of surface filter usually known as “screening” process while depth filter usually will

make the used lube oil have a higher resistance to flow. In other words, depth filter has a higher possibility to clean out more contaminants from the used lube oil.

In addition, each of the filters has its own filtration ratio. It is also known as Beta Rating. Based on the rating, the efficiency of the filter can be easily determined. The higher the Beta Rating, the higher the efficiency of the filter. When the efficiency of the filter higher, more contaminants will be trapped in the filter. Due to that, the quality of the used lube oil that undergo a filtration process will be improved.

In order to ensure that the filtration process of used lube oil can be done smoothly, several types of the filtration process that have been studied and it have been chosen to improve the quality of the filtration process. There are five types of filtration process which is media based filtration, magnets, coalescing systems, centrifugal systems and vacuum dehydration.

Besides that, the filtration media also need to be studied because it is important to choose the suitable material for the filter. If the material used for the filter is not suitable for the filtration process, the filter will become ineffective and useless. Then, the contaminants also will not be trapped. So, there are three types of filtration media that have been used in this redesign process of filter which is pleated microfiber glass, polypropylene and activated carbon.

In fact, the filter already have been made by someone else before this. But in order to get the best result in terms of the properties of the used lube oil and to increase the quality of the recycle used lube oil, the new filter will be designed. For the engineering design process, the redesign process is chosen in order to create an improvement to the current design of the filter. SolidWorks is one of the components in Computer Aided Design (CAD) is used in order to redesign the filter.

The used lube oil also will be tested in order to prove that the redesigned process of the filter have success in improving the quality of the used lube oil. In order to test the properties of the used lube oil, the oil analysis testing is conducted. In other words, Rotating Disc Electrode Atomic Emission Spectroscopy (RDE-AES) and Viscometer will be used.

1.2 Problem Statement

The used lube oil that has been produced can be considered as a source or as a resource of environmental pollution (Emam & Shoaib, 2012). Environmental pollution can be defined as the physical and biological composition that was affected and contaminated, resulting in a change in the natural ecosystem and adversely the environmental processes (Gray, 2012).

Usually, the used oil will be dumped to the toxic waste disposal sites for disposal process. This is because used oil is one of the material wastes. Used oil needs to be managed properly and carefully because if it is wrongly handled, it can become severe to the environment. There are possibilities that the increment usage of the used oil will make the solid waste disposal sites are no longer able to accommodate all the material wastes. This scenario will lead to the environmental pollution. In order to avoid the disposal of the material wastes from becoming uncontrollable, the used oil needs to be recycled.

Besides that, there are high demand for the oil in the industries and this will affect the oil reserve. In other words, the decrement of the oil sources will occurs. Due to that, it will contribute to the increasing of the petroleum price each year. The impact of this scenario, an initiative such as filtration process of the used oil must be done to approach a way to make oil as a renewable sources. This initiative will be a solution to save the environment and to avoid the depletion of oil.

In addition, the production of new oil needs a lot of cost. The reuse of the used oil can reduce the cost of the production to make a new oil. It also can save crude oil supply. Due to that, the recycle of the used oil can make the used oil become reusable. When the used oil become a renewable sources, there is no more cost needed in order to produce a new oil.

Used oil should be undergoing the filtration process to make it reliable again. In the current design of the filtration aids, there is only a slight change that occurs to

the properties of the used lube oil. So, the filtration aids should be redesign to improve the properties of the used oil

1.3 Objectives

From the problem statement that have been stated, the purpose of this research is:

i To determine the regeneration process of used lube oil.
ii To determine which types of filter is more suitable and proper for the used lube oil filtration process.
iii To improve the design of the used lube oil filtration process.
iv To analyse the properties of the used lube oil after the improvement of the filtration process.

1.4 Scopes

In order to achieve the objectives of the study, several scopes have been identified:

i Determining the regeneration process of used lube oil based on the previous research.
ii Determining which types of filter is more suitable and proper for the used lube oil filtration process.
iii Improving the design of the used lube oil filtration process using SolidWorks software.
iv Analysing the improvement of the properties of the used lube oil after undergoes the filtration process by using Rotating electrode optical emission spectrometry (RDE-AES) and Viscometer.

CHAPTER 2
LITERATURE REVIEW

2.1 Lubricant

Lubricant is used on many equipment and machinery to ensure that no failure occurs in the equipment and machinery during the run time. It provides a film coating on the surface of material to avoid the degradation of the surface and reduce the surface roughness of the material (Khonsari & Booser, 2001). Film coating will avoid the surface of material from the resistance when moving over another surface. Thus, this will smoothen the movement between the surfaces. Besides that, it also reduces friction, wear and heat production.

In the engine system, lubricant plays an important role to seal out contamination. Without lubricant, the component of the engine will not run efficiently. Thus, the combustion process will not be performed smoothly. In addition, the disturbance efficiency of the engine due to the friction by sliding between the components of the engine system. This will lead the engine system to overheat and causes wear to the engine components (Pirro & Wessol, 2001). So, lubricant is important to prolong the life of a component in the engine system. Therefore, lubricant is needed to overcome this problem with proper monitoring and maintenance.

2.2 Type of Lubricant

There are many variations of the lubricant depends on its function and purpose. Each type of lubricant is specialized only for a certain circumstance. If lubricant is not applied in the right circumstances, the lubricant will not bring any benefits. Furthermore, it only causes the component of the equipment will be overheat and seizing.

2.2.1 Solid Lubricant

Solid lubricants provide thin films of a solid between two moving surfaces to reduce friction, wear and to facilitate the movement of two contacting surfaces. The mechanism occurs when there are two contact surfaces of material slide over between each other and molecule of solid lubricant will roll, this will facilitate the movement of the surface. When there is too much of solid lubricant applied between two contact surfaces, each molecule of solid lubricant will roll and it will increase the friction between molecules. It will contribute to increasing the rate of wear. Figure 2.1 below shows the mechanism of solid lubricant.

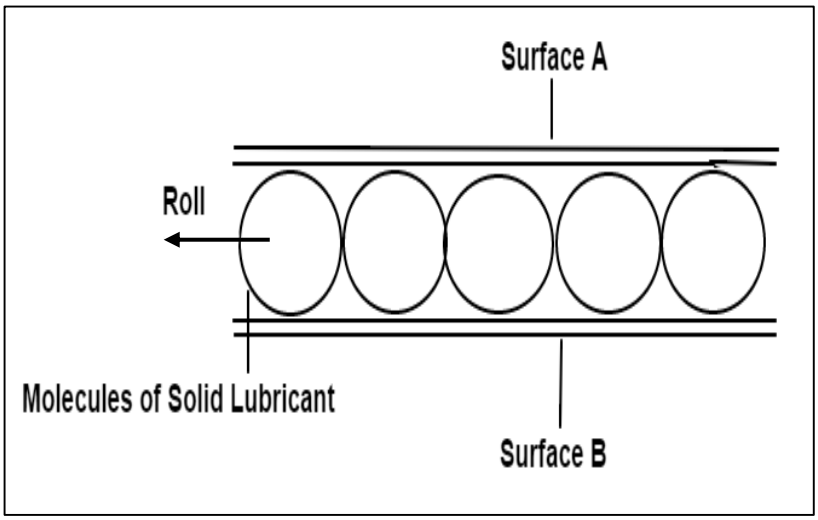

Figure 2.1: The Mechanism of Solid Lubricant

Solid lubricants usually used for high temperature, aerospace, vacuum, nuclear radiation, and other circumstances that not tolerated by liquid and semi-solid lubricants. In addition, the common type of solid lubricants are Molybdenum disulphide (MoS_2), Graphite and Calcium fluoride-barium fluoride eutectic (Ca_2 – BaF_2) (Khonsari & Booser, 2001).

2.2.2 Liquid Lubricant

It is in a liquid form. It provides a film of liquid between two moving surfaces according to the viscosity. If viscosity is thin, it will produce thin films on any lubricate surface. So, when two contacting surfaces are moving, the surfaces still collide and contact each other. This type of lubricant usually applied to the heavy machinery. While, when the viscosity are thick, it will produce thick films between the surfaces. Thicker films of lubricants give a total separation between two contacting surfaces. It is usually applied to the speedy machinery.

Liquid lubricant is a common type of lubricant that used in the engine system. This is due to the properties of liquid lubricant that can smoothen the movement of the component in the engine system and can make the engine system well function. Lube oil is one of the examples of the liquid lubricant. Table 2.1 shows advantages and disadvantages of the lube oil.

Table 2.1: The Oil Comparison Chart (Bannister, 2007)

Advantages	Disadvantages
• Easy to apply • Oil lube systems are usually less expensive than grease • Excellent cleaning and flushing characteristics • Can be used in recirculating systems	• Hard to control • Could contaminate product and machinery • Correct viscosity selection is critical in retaining food performance • Susceptible to temperature variations

• Within systems, generally more stable as a lubricant than grease • With correct application, no limit to machine speed	• Susceptible to leakage

2.2.3 Semi-solid Lubricant

Semi-solid lubricant is lubricating oil thickened with a gelling agent such as non-melting powder or metallic soap. In addition, semi-solid lubricant are given first consideration for lubricating ball and roller bearings in electric motors, aircraft accessories, household appliances, machine tools, automotive wheel bearings, instruments, railroad, and construction equipment. It also commonly used for low-speed sliding application and small gear units (Khonsari & Booser, 2001). Grease is a common example of semi-solid lubricant.

There are 9 reasons grease are chosen as a lubricant:

i Provide adequate lubrication to reduce friction and to prevent harmful wear of components.
ii Protect against rust and corrosion.
iii Act as a seal to prevent entry of dirt and water.
iv Resist leakage, dripping, or undesirable throw-off from the lubricated surfaces.
v Retain apparent viscosity or relationship between viscosity, shear, and temperature over useful life of the grease in a mechanical component that subjects the grease to shear forces.
vi Not stiffen excessively to cause undue resistance to motion in cold environments.
vii Have suitable physical characteristics for the method of application.
viii Be compatible with elastomer seals and other materials of construction in the lubricated portion of the mechanism.
ix Tolerated some degree of contamination such as moisture without loss of significant characteristics