A STUDY OF SUNFLOWER OIL PERFORMANCE AS A GEAR LUBRICANT

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SUPERVISOR DECLARATION

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation)"

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This thesis is submitted in partial fulfilment of the requirement for the award of a Bachelor Mechanical Engineering (Design & Innovation)

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DECLARATION

"I hereby declare that the work for this whole project and report is on my ideas except for quotations and summaries which have dully acknowledged."

Signature : .....
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ABSTRACT

In manufacturing and automotive industry, gears are the most crucial character in those fields. A set of gears is used to provide a method to change the torque from rotating object in order to move a certain load. Continuous metal to metal contact will cause rapid wear without sufficient lubrication provided. Lubricant must give protection to the gear in against corrosion. Gear lubrication is not an easy matter. Proper selection of good lubricant properties can prolong gear life and enhance the reliability of gearbox. Instead of synthetic lubricant, vegetable based oil has large potential in replacing other lubricant especially synthetic type lubricant. Vegetable oil is highly recommended, though it gives no harm effect towards our nature as it exhibit a biodegradable and renewability properties. Many study has prove that vegetable oil chemical structure has a great influences towards its behavior, especially physical properties. In this study, sunflower oil is used in the gearbox. Its composition has affected the temperature ability where vegetable oils have poor low temperature behavior. Triglycerides structure and fatty acids composed in vegetable oils give instability in oxidation. When selecting lubricant, temperature at the contact area and ambient temperature are important factors to be considered. Besides, VI plays an important character in gear lubrication. By using experimental method and lubrication analysis, vegetable oil is found to have high VI up to 241 and has poor oxidation stability. It's also has poor low temperature behavior. These two disadvantages concluded that sunflower oil has low performances as a gear lubricant.

ABSTRAK

Di dalam industri pembuatan dan automotif, gear merupakan bahagian paling kritikal. Satu set gear adalah kaedah yang digunakan bagi mengubah daya kilas lalu memutarkan gear tersebut bagi mengerakkan sesuatu beban. Dua bahan logam yang yang sentiasa bergeseran akan menyebabkan permukaan tersebut cepat haus sekiranya tidak diberikan kadar pelinciran yang secukupnya. Pelincir mesti memberi perlindungan kepada gear supaya tidak terdedah kepada hakisan. Pelinciran gear bukanlah suatu perkara yang mudah. Pemilihan pelincir yang betul boleh memanjangkan jangka hayat peralatan dan meningkatkan kebolehpercayaan kotak gear. Minyak berasaskan sayur-sayuran mempunyai potensi yang besar untuk menggantikan minyak pelincir jenis lain terutamanya pelincir sintetik. Minyak sayur-sayuran adalah sangat disyorkan, kerana ia tidak memberi kesan bahaya kepada alam semula jadi dan berupaya untu menjadi bahan yang boleh diperbaharui. Banyak kajian telah membuktikan bahawa struktur kimia minyak mempunyai pengaruh yang besar terhadap tingkah sifat fizikalnya. Komposisi minyak sayuran sendiri telah menjejaskan keupayaannya ketika di paras suhu rendah. Struktur trigliserida dan asid lemak yang terdapat dalam minyak sayur-sayuran menyebabkan ketidakstabilan dalam pengoksidaan. Apabila memilih minyak pelincir, suhu di kawasan *'contact'* gear dan suhu persekitaran adalah faktor penting yang perlu dipertimbangkan. Selain itu, indeks kelikatan, memainkan peranan yang penting dalam pelinciran gear. Dengan menggunakan kaedah eksperimen dan analisis pelinciran, minyak sayur-sayuran didapati mempunyai index kelikatan yang tinggi sehingga 241 dan mempunyai ketidakstabilan pengoksidaan dan paras suhu rendah yang tidak memuaskan.

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LIST OF SYMBOLS

v	=	Kinematic Viscosity
η	=	Dynamic Viscosity
ρ	=	Dwensity
m	=	Mass of Oil
g	=	Gram
l	=	Litre
V	=	Volume of Oil
%	=	Percent
℃	=	Degree Celcius

LIST OF ABBREVIATIONS

AC	Alternating Current
AGMA	American Gear Manufacture Association
API	American Petroleum Institute
ASTM	American Society of Testing and Material
BC	Before Century
cP	Centipoise
cSt	Centistoke
EP	Extreme Pressure
FZG	Forschungsstelle fur Zahnrander und getriebebau
OEM	Original Equipment Manufacturer
R&C	Rust and Oxidation
SAE	Society of Automotive Engineering
STLE	Society of Tribologists and Lubrication Engineers
VI	Viscosity Index
VG	Viscosity Grade

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

For the past several years vegetable oil has been identified to be used as gear lubricant. It has same potential as common synthetics lubricant. These oils propose important environmental benefits with regard to resource renewability and biodegradability, as well as provide adequate performance in a broad range of application. Besides, the range price for vegetable oil is lower than synthetics oil.

Biodegradable means a substance that is able of being decomposed by bacteria and other living organism. Vegetable oil waste gives no harm effect to environment especially soil where in a particular time the fluid is converted to a lower molecular weight component.

Environmentally reconcilable lubricants oil is progressively being used, for example in motor vehicle and equipment in water protection areas and in hydraulic engineering, in vehicle for agriculture and forestry. This oil is overtly degradable, non toxicity and the water hazard is low (Antonsson, 2009).

Application of vegetable oils in industry is to support world concern towards Green Technology. Due to environmental concerns, vegetable oil finding its solution

into lubricants for industrial and transportation application where scientists, engineers and inventors should know that green invention and technologies are good to our mother earth and can reduce energy bill, indeed offer safer and healthier products. Based on Condition Based Maintenance that has been implemented in nowadays industry, lubricant analysis is one of the ways to show that equipment is going to work well or fail in term of performance. Advance inspection can help engineer and maintenance team to identify the performance of vegetables oil as gear lubricants. The importance of good lubrication usually was not really been stress until a failure happen and has lead to equipment failure and profit loss as the production was suspended. Bad maintenance practice was one of the main reasons that caused the problem. Therefore, lubricant analysis is beneficial to promote a good lubrication practices. The main purpose of the lubricant analysis in this study is to evaluate the performance of a sunflower oils which is a vegetable based oil is either have a potential in substituting synthetic lubricants which not readily biodegradable and expensive.

The primary function of lubrication is to help preventing excessive friction. Maintenance team must hold the responsibility in purchasing lubricants where it should be purchased on specification not because a matter of price. With the trend toward higher appreciation on earth has lead to many case studies on performance of vegetable oils and its chemical structure shows that it has superior benefits. Performance of vegetable oil has its constraint where its base stock have poor oxidative stability and low temperature solidification.

1.2 OBJECTIVE

The purpose of this research experiment is to evaluate sunflower oil as a gear lubricant. The evaluation is based on experimental method.

1.3 SCOPE OF WORKS

This experiment used gear test rig approached which is personally fabricated to investigate performance of sunflower oil as gear lubricant. Helical gear is used in the test rig and will be run for hours and sample of lubricant will be analyzed. The test will be held at Faculty of Mechanical Engineering Workshop at Mars Campus.

1.4 PROBLEM STATEMENT

Common synthetics lubricant show low biodegradability of 70% to 95% compare to vegetable oil which is 80% to 95%. For century, synthetic oils have predominant lubrication and today the environmental issue start to arise as synthetic oil is not readily biodegradable. Vegetable oil composes good physical properties to replace synthetics oil but its performance is questionable. At the end of semester, a full report will be submitted. All these step of methodology is illustrated as a flow chart shown in Appendix A. In addition, Gantt charts for the research are shown in Appendix B.

1.5 CONCLUSION

The objectives and scope are the important criteria that will be set as a guideline to achieve the study according to the flow chart as shown in Appendix A. Gantt chart plays important role as a ruler to help accomplishing this study in given time.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter a brief and deep explanation which is engaged to the study including the classifications of lubricant, the importance of lubricant, composition of vegetable oil, parameter involved such as VI, temperature and kinematic viscosity which is essential to determine VI. This chapter has key concepts like the advantageous and inherent limitations of vegetable oils and the system use to identify the grade of oil and synthetic lubricant explanation which is used as a reference in evaluating the performance of vegetable oil.

2.2 THE IMPORTANCE OF LUBRICANT IN GEARBOX

In minimizing friction of mating parts the use of lubricant is necessary. Generally, proper use lubricants prolong the life of equipment and also minimized unpredicted failures. Lubricant is often used in gearbox where two sliding gears are in it. Sliding metal usually will have friction. Without lubricant, sliding part creates extreme friction and requires a great amount of energy to rotate the gears. The application of lubricant fluid in the gearbox provides few primary benefits which are;

1. To lubricate the teeth and to remove heat generated from the gear operation
2. To reduce friction and wear in sliding components to prevent premature failure
3. To ensure a good cushioning for gear operation.
4. Reduction of operating noise.
5. Improvement in heat transfer.
6. Corrosion prevention.

A good selection of gear lubricant will provide slip-free for gear transmission, spare a good reliability gearbox, low maintenance and long-life.

Lubrication fully or half distinct the surfaces of the friction bodies by selectively introducing an interfacial medium which is lubricant that reduces friction. It is proven that the minimum lubrication film thickness increases as the entraining velocity increases and the viscosity becomes greater, and that it decreases as the loads increase, although only with an exponent of 0.5 inch each case. The minimum lubrication film thickness is normally greater than 1μm (Antonsson, 2009).

Appropriate lubrication is essential to avoid premature wear of gear tooth surfaces because gear shift greatly in their design and lubrication type. When choosing lubrication for gear application the following terms must be considered which are type and materials, operating conditions, speed, load and temperature, environment and type of service.

Enhance test and experiment in determining the performance of gear lubricants have lot of beneficial outcome especially for maintenance material planning and control teams. It is often said that the test rig practice is significant and satisfied the standard regulated by registered society. The importance of advance test can avoid repetitive breakdowns in nature. Careless selection of lubricant can lead to a failure called lubrication related failure.

Some constraint of vegetable oil performance such as anti-wear protection, load carrying capacity, rust prevention, foaming and demulsibility are mostly additive-dependent. The base stock dependent of vegetable oil must be initially evaluated when a specific type of vegetable oil is acceptable as a contingent base stock for industrial or automotive application (Erhan and Perez, 2002).

2.3 CLASSIFICATIONS OF LUBRICANT

Lubricant can be classified to four categories which are mineral lubricants, synthetic lubricants, vegetable lubricants and animal lubricant.

1. Mineral fluid lubricants are based on mineral oils. Mineral oils or known as petroleum oils are products of refining crude oil.
2. Synthetic lubricants are lubricant fluid which built up with chemical structure and properties.
3. Vegetable lubricants are based on soybean, corn, castor, canola, cotton seed, and rape seed oils. Vegetable lubricants type is environmentally friendly alternative to mineral oils since they are biodegradable.
4. Animal lubricants are produced from animals' fat. There are two main animal fats: hard fats also called as stearin and soft fats. Animal fats are mainly used for manufacturing greases.

In this experiment, the lubricants that will be used are a natural vegetable based lubricant which is sunflower oil. This type of lubricants were widely used in industry plus it is easy to get and cheaper than synthetics lubricants. It is also non-toxic where fatty acids composed in vegetable oil generally non toxic to aquatic and terrestrial environments. Vegetable oils based lubricant has greatly more capable in diminishing the level of carbon monoxides and hydrocarbon emissions.

Vegetable oils can be classified into two categories which are edible vegetable oils and non edible oil. Edible oil is produced in great amounts worldwide and is mainly used for edible purposes. Palm oil, sunflower oil, olive oil and coconut oil are the example of edible oils. Non edible oils are mainly used for commercial purposes instead for edible purpose. The oils are castor oil, jojoba oil and jatropa oil (Chatra et al. 2012).

2.4 VEGETABLE OIL AS A LUBRICANT

Lubricants can be in liquid or solid. Liquid lubricant consists of a mixture of base oil and additives which are blended to a specific viscosity and it is designed to meet the performance needs of particular type of service (Eugene et al. 2006).

The idea of using vegetable oil in industry is not new since it's has been used in engine. The original diesel engine that Rudolph Diesel designed ran with vegetable. He used peanut oil to fuel one of his engines at the Paris Exposition in 1900 (Bassam, 2010). Vegetable oils is said to be biodegradable and this behavior has become one of the more important design parameters both in the selection of the base fluid and in the overall formulation of the finished lubricant. This type of lubricant product gives no environmental impact where in a specified time the fluids are converted to lower molecular weight components so it is safe to our nature indeed. Vegetable oils waste is rapidly removed from the environment by natural process in the event of a leak or spill, and low eco toxicity. Biodegradable is related to its chemical structure where its affect their properties. It is identify through various test carried by chemical experts.

Biodegradability of vegetable oil was tested in Finland by pouring 10 *l* of the oils on the soil. After six to seven weeks, the oil sample is entirely disappeared (Chatra et al. 2012). Vegetable oils are used in the stable and meta stable emulsions and may contain fatty alcohols. It's also provided better anti wear performance and generally exhibit

lower friction coefficients (Perez et al. 2013). The use of vegetable oils as lubricants is not surprising because they naturally possess good natural lubricity.

The vegetable oil has been used by human since ancient time. Olive oil was used as a lubricant as long ago as 1650 BC (Gawrilow, 2003) . In Europe there have been quite a lot of developments on the environmentally acceptable lubricants. There are guidelines and legislation books such as Blue Angel Guideline of Germany and The Austrian water protection regulation books. Table 2.1 shows the biodegradability level of various base oils. Vegetable oil and synthetic ester show good biodegradability (Yeong et al. 2005).

Table 2.1: Biodegradable level of selective oil

(Source: Yeong et al. 2005)

Biodegradability of Base Oils	
Mineral oils	30 – 70%
White mineral oils	30%
Polyethers	20 – 70%
Polyethyleneglycol	50 – 80%
Synthetic esters	70 – 95 %
Vegetable Oils	80 – 95%

The enormous demand will be in Europe and Canada. This country has become strongly concern about their environmental problem. The increment of environment awareness among them had leaded them toward a keen investigation about the production of vegetable oil as lubricant. It is seen as a potential source of environmentally favorable lubricants due to combination of biodegradability, renewability and excellent lubrication performances.