UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFICIENT PLANNED MAINTENANCE SYSTEM FOR AUTOMOBILES ENGINE BY MEANS OF OIL BASED CONDITION MONITORING – A CASE STUDY OF UTeM STUDENT BUS

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

NURFARAHIN NAJWA BINTI MOHD RAZAK

B071110139

920611145922

FACULTY OF ENGINEERING TECHNOLOGY

2015

DECLARATION

I hereby, declared this report entitled "Efficient planned maintenance system for automobiles engine by means of oil based condition monitoring – a case study of UTeM student bus" is the results of my own research except as cited in references.

Signature : _____

Author's Name : NURFARAHIN NAJWA BINTI MOHD RAZAK

Date : _____

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's in Mechanical Engineering Technology (Maintenance Technology) (Hons.). The member of the supervisory is as follow:

……..

(Project Supervisor)

ABSTRAK

Tujuan utama kajian ini adalah untuk mengkaji pelincir berdasarkan proses pemantauan dan pelaksanaannya pada penyelenggaraan kenderaan. Pemantauan keadaan minyak dilakukan untuk menilai dan menentukan sama ada pelincir ini sesuai untuk kegunaan selanjutnya. Prosedur penyelenggaraan yang sedang dijalankan pada bas pelajar UTeM adalah beasaskan masa dan penyelenggaraan yang dibuat berdasarkan jarak. Walau bagaimanapun, kedua-dua prosedur ini boleh menjejaskan kecekapan pada keseluruhan penyelenggaraan. Pemantauan keadaan minyak dijalankan untuk pelincir bas pelajar UTeM dan membuktikan jika ia adalah prosedur penyelenggaraan yang berkesan untuk digunakan. Kelikatan, titik nyala dan analisis serpihan hakisan dalam minyak dipilih sebagai parameter untuk dianalisis. Kaedah eksperimen digunakan untuk menganalisis pelincir bas UTeM. Kedua-dua jenis minyak; minyak baru dan minyak yang telah digunakan oleh bas pelajar UTeM diperiksa bagi setiap parameter. Kajian ini menggunakan tiga jenis kaedah ujian; ASTM D93, ASTM D6595 dan pemanasan kelikatan kinematik. Keputusan analisis menunjukkan bahawa terdapat hanya dua sampel yang melebihi had ± 15% kelikatan kinematic yang ditetapkan. Takat kilat menunjukkan penurunan pencairan bahan api. Tindakan pemulihan seperti penukaran minyak perlu dilakukan jika takat kilat itu kurang daripada 170 ° C. Hasil pada serpihan hakisan dan analisis lima elemen menunjukkan penurunan hakisan dan kesusutan bahan tambahan yang biasa. Ini dapat disimpulkan bahawa terdapat perbandingan yang ketara dalam penyelenggaraan berdasarkan jarak dan penyelenggaraan berdasarkan keadaan oleh analisis minyak. Pemantauan berasaskan Keadaan ini terbukti lebih berkesan kerana sistem penyelenggaraan ini mempunyai proses yang tepat dalam mengenal pasti

keadaan minyak dan segera meramalkan sama ada komponen enjin mempunyai masalah atau tidak.

ABSTRACT

The main purpose of this research is to study the oil based condition monitoring and its implementation on maintenance of automobiles engine, in this case, UTeM student bus. Oil based condition monitoring is conducted to determine the condition of the lubricant and evaluate whether or not the oil is suitable for further use. The current maintenance procedures applied on UTeM student buses are time based maintenance and maintenance based on mileage. However, both procedures can jeopardize the overall efficiency of the maintenance. In this study, oil based condition monitoring is performed to the lubricant of UTeM student bus and proves if it is the effective maintenance procedure to be applied. Viscosity, flash point and wear debris are selected as the parameters to be analyzed. Experimental method is used to analyze the lubricant of UTeM buses. Both fresh (new) oil and used oil of the UTeM student bus is examined for each parameter. This study uses three types of test methods; ASTM D93, ASTM D6595 and by using heated kinematic viscometer. The result of the analysis indicates that there are only two samples that exceeded the limit of ±15% of kinematic viscosity. Also it can be observed that the flash point decreases which indicates fuel dilution. It is suggested that oil change is carried out if the flash point is depressed to less than 170°C. The result on wear debris and analysis on the five elements shows a normal wear and depletion of additives characteristic. It can be concluded that there is definite significant in the comparison of mileage based maintenance and condition based maintenance by oil analysis. Condition based monitoring is proven to be more effective as maintenance system due to its accurate

process of identifying the condition of the oils and right away predicting if the engine component having problems or fails.

DEDICATION

The hardship on executing this project is dedicated to my beloved parents, family, dearest classmates, and my adored best friends for the support and indulgence of easing till the completion of this project.

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to Dr. Olawale Ifayefunmi for his supervision, encouragement, suggestions throughout the duration of this research. I would also like to express my gratitude to Encik Muhammad Azwar bin Azhari for his advice and suggestions in the subject condition based maintenance and oil analysis. Special thanks to UTeM short term grant funding for the financial support throughout this project.

Also I would like to express my big thanks to my colleagues for their support and time during my research study namely Ms Norehan Kasiman and Ms Nur Nabilah Anuar. I would like to thank the staff of UTeM vehicles management for their cooperation in providing the samples.

Last but not least, I would like to thank my mother, my father, my family, and my peers for giving me their full support, understanding and patience. Without their support, I would not have been able to finish my research project.

TABLE OF CONTENT

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM	-	American Standard of Testing and Materials
CBM	-	condition based monitoring
COC	-	Cleveland Open Cup
cSt	-	Centistokes
FT-IR	-	Fourier Transform Infrared
ICP-OES	-	inductively coupled plasma atomic emission spectroscopy
km	-	kilometre
SAE	-	Society of automotive Engineers
TBM	-	Time based maintenance
US	-	United State
UTeM	-	Universiti Teknikal Malaysia Melaka
ZDDP	-	Zinc Dialkyl Dithiophosphate

CHAPTER 1
INTRODUCTION

1.1 Background of study

1.1.1 History of maintenance

Since the dawn of time, humans have always felt the need for the maintenance of their equipment, even the most basic tools. Most of the failures experienced have been as a result of continuous use without any sort of conserving act toward the machinery, as it sometimes still happens. Maintenance was only being done when it was no longer possible to run it.

As stated by Brown and Sondalini (2004), prior to the Second World War, machinery was generally quite rugged and relatively slow running. There instrumentation and control systems were very fundamental. The claims of production were not overly severe so that downtime was not usually a critical issue and it was sufficient enough to maintain on a breakdown basis. This machinery was inherently reliable. Even today we can see examples of machines made in that period which have worked very hard and are still essentially as good as the day they were made.

Brown and Sondalini (2004) also stated that from the 1950's with the reconstruction of industry after the war, Japan and Germany had developed a much more competitive marketplace; there was increasing intolerance of downtime. The cost of labour became increasingly significant leading to more and more automation and mechanisation. Machinery runs at higher speeds. They wore out more rapidly and were seen as less reliable as they were utilized more fully.

1.1.2 Oil-based Condition Monitoring

Maintenance is defined as a set of activities of tasks used to restore an item to a state in which it can perform its designated function. Condition-based monitoring is the most popular and modern maintenance technique. It is a maintenance program that recommends maintenance actions based on the information collected through condition monitoring process (Ahmad & Kamaruddin, 2012).

In condition-based maintenance, the lifetime of the equipment is monitored through its operating condition; vibration, temperature, lubricating oil, contaminants, and noise levels. Lubricant monitoring is where the condition of the oil is evaluated to determine whether or not the oil is suitable for further use. According to Perić and Nedić (2012), the use of a lubricant inevitably leads to the decline of its performances. These negative changes are most usually caused by influence of different kinds of pollution, thermal load, etc to which the lubricants are exposed during service. As a result of high mechanical loads or prolonged exposure, it can lead to increased in temperatures. Different kinds of pollution are also a frequent cause of lubricant degradation. Gaseous combustion products, water, air, wear products, and other pollutants, may be the cause of a serious decrease of the condition of the lubricant. It also affects the machinery itself. That is why it is necessary to monitor changes in lubricant's performances, thus increasing the lubricant's service life and preventing any major failures or damages to the system.

1.1.3 Lubricant

Lubricant is the life-blood of machinery. Much like doctors appraising our health through blood analysis, critical machinery equipment must be monitored in much the same manner. According to Perić & Nedić (2012), the basic role of lubricants is to reduce friction and hence prevent the wear of material surfaces whose relation is conditioned by relative mutual movement. Chronic lubricant or equipment symptoms show up as indicators in oil analysis samples and, if left uncorrected, can lead to productivity lost and equipment degradation. Therefore, the goal of a productive oil

analysis program is to trace gradual changes in fluid properties, wear debris and contaminants so that counteractive action can be initiated in a controlled and planned manner. In this project, the lubricant used is the Shell Rimula R4X 15W-40 (CI-4). This energized protection oil gives maximum soot handling. It also delivers excellent wear protection on life in Euro 3, US 2002 and other advanced engine. However, each lubricant will reach it functional life span and the point where the lubricant serviceability decrease. The lubricant serviceability can be impacted by contamination levels that have reached a point requiring a drain and refill, unless purification is an option (Sewell, 2009).

Figure 1.1: Shell Rimula R4X 15W-40

Figure 1.1 shows the types of lubricant oil that is used by UTeM vehicles management for their buses and taken as samples for this experiment. In this project, attention is focused on lubricating oil of automobile engine, for monitoring the operating condition of UTeM buses. Three parameters will be examined during this project namely kinematic viscosity, flash point and elemental analysis. The methods use to analyze the oil will be the heated kinematic viscometer, ASTM D93 flash point by "Pensky-Martens closed cup", and ASTM D6595 rotary disc emission (RDE) spectrometry as stated by Gresham and Totten (2009). The required data

determination and collection will lead to performance of data analysis and then to decision making.

1.2 Problem statement

Recent survey on the maintenance system of UTeM bus shows that UTeM is currently applying two type of maintenance system on their student buses. One is maintenance based on mileage. UTeM runs maintenance on their buses when the mileage reaches 5000km. However, the mileage for when the buses lubricant will reach their functional life span cannot be verified.

The other one is maintenance based on time and the activity is executed during a specified periods. UTeM sent their buses for maintenance every three month intervals. Unfortunately, time-based maintenance includes labor intensive and performance of unneeded maintenance. This type of maintenance can also jeopardize the overall efficiency of the maintenance system conducted. Sullivan et al. (2010) said that catastrophic failures can likely occur again and extensive labor needed when undergo this maintenance. Youngk (2000) stated that the technical improvements for automobile engine have been significant in nearly all areas including oil formulation, filtration, bearing design, and engine design. Zhu, et al. (2013) stated that providing an early warning of the machine failure is important. Therefore, the aim of this project is to monitor the oil degradation process of the lubricant used by UTeM buses in order to provide early warning of machine failure as demonstrated thereby suggesting efficient way of carrying out maintenance system.

1.3 Objectives

The objectives of this project are as follows:

i. To study the oil based condition monitoring and its implementation on maintenance of automobiles engine.
ii. To compare the significant between the current maintenance procedure on UTeM buses and oil condition based monitoring on oil analysis.

1.4 Scope

The scopes of this project are as follows:

i. Collection of samples (12) of used lubricant oil by UTeM buses from the workshop.

ii. Analysis of the oil samples using three types of test methods; using a heated kinematic viscometer, ASTM D93 flash point, and ASTM D6595 rotary disc emission spectrometry to obtain the kinematic viscosity, flash point and wear debris result.

iii. Comparison of analyzed result of used oil with a fresh oil (as manufactured).

iv. Examination of the influence and appropriation of the maintenance system employed for each sample in comparison with oil based monitoring system.

v. Provide recommendation on the efficient planned maintenance system to be employed by the management of UTeM vehicle.

Figure 1.2: Difference in the appearance of fresh oil and used oil

Figure 1.2 shows the difference in the appearance of fresh oil and used oil. Used engine oils has a dark black appearance and thick consistency compare to other used

lubricant oils. This is due to the process of oxidation. Oxidation as a result of the oil molecules reacting and joining together causing the oil to becomes thicker and darker.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter presents theoretical background on the theory of maintenance system for this project. The work will be organised with a literature search focusing on efficient planned maintenance system, predictive maintenance, oil based condition monitoring and the parameter for this project oil analysis.

The purpose is to review previous studies on what others have done similar to the scope of this project and use the information as a foundation and support for this project. Data evaluation is done by determining which literature makes a significant contribution to the understanding of the topic. Analysis and interpretation on the journals related is done by discussing the findings and conclusions of literature that correlate with this project.

2.2 Planned Maintenance System

Planned Maintenance is defined as maintenance activities performed on a pre-determined schedule of activities. Planned maintenance is usually carried out by the maintenance department and must be coordinated with the autonomous maintenance activities of the operations department so the two departments can function together.

Many companies still use a system of planned or routine maintenance to avoid costly down-time arising from the failure of equipment and machinery assets. In other words they replace parts that tend to wear out on a routine basis whether they need replacing or not.

Condition based maintenance (CBM) relies on the fact that the condition (degree of wear) of the asset is routinely monitored and only replaced when its condition deteriorates beyond an acceptable level. This decision is based on recording and tracking the changes in the asset's condition over time (trending).

This obviously saves money since asset parts are only changed when they need to be. Additionally, condition monitoring can potentially save a lot of money by spotting a part that is about to fail prematurely before it fails hence avoiding an unexpected and costly shut-down. Clearly condition monitoring is a superior technique but until now its cost has prevented many companies from using it. Traditionally, both the condition monitoring equipment and the expertise required to carry out an analysis of the asset's condition has been prohibitively expensive.

2.3 Types of Maintenance System

2.3.1 Time Based Maintenance

Time based maintenance (TBM) is also known as the preventive maintenance. It is time-based activities such as changing lubricant based on time, like calendar time or equipment run time.

This is supported by a statement by Yam, et al. (2001). Yam, et al. (2001) stated that TBM is also called periodic preventive maintenance. In order to slow down the deterioration processes leading to failures, preventive maintenance is carried out by periodically lubricating, calibrating, refurbishing, inspecting, and checking of equipment on a regular scheduled basis.

2.3.2 Mileage Based Maintenance

Fixed mileage maintenance can be carried out where there is a known relationship between miles or kilometres travelled and failures. This type of maintenance has a degree of chance variation unlike condition based maintenance. The life span of the oil does not necessarily fails at it reaches a certain mileage.

For example, a specific transmission model has shown a history of failure at 150,000 miles. So a manager initiates a campaign to overhaul the transmission before the vehicle reaches 150,000 miles. No concern is given to the actual condition and performance capability of the oil. This methodology would be analogous to a preventive maintenance task (Sethiya, 2006). Some transmissions will be repaired long before they might otherwise fail. However, if the failure pattern is predictable, then this type of maintenance on selected components is appropriate as it eliminates a disabled vehicle, an in-service failure, and the costs incurred by performing an unscheduled repair. The maintenance manager can schedule work flow more efficiently and reduce road calls while increasing service reliability (Anon., 2010).