UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

DEVELOPMENT OF WIRELESS ENGINE LUBRICATION OIL LIFE ALERT SYSTEM

Tin Shaw Liang

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DECLARATION

I declare that this thesis entitled "Development of Wireless Engine Lubrication Oil Life Alert System" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is concurrently submitted in candidature of any other degree.

Signature	:	…………………………….
Name	:	TIN SHAW LIANG
Date	:	…………………………….

APPROVAL

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 for the award of Master of Science in Manufacturing Engineering.

Signature	:	………………………………………..
Supervisor Name	:	………………………………………..
Date	:	………………………………………..

DEDICATION

This thesis is dedicated to my father,

Tin Ang Tee @ Chan Swee Chin

for supporting and encouraging to believe in myself.

To my beloved mother,

Lim Mang Moi

for all support that you have given to me.

For my sisters,

Tin Shaw Jiun & Tin Shaw Yi

for never give up on supporting and encouraging me.

ABSTRACT

Engine lubricant plays a significant role in reducing internal friction between the piston and shear of moving mechanical parts. Besides, it also improves engine performance and efficiency. Rapid developments in engine oil monitoring systems have taken place to determine that the engine lubricant degradation level is attuned towards reducing unnecessary engine power loss and maintenance cost. However, the accuracy of the engine monitoring systems can be affected by surrounding conditions, such as temperature, pressure and lubricant content whereas the conventional oil-changing strategy according the distance travelled is not efficient as the rate of oil degradation is different based on the type of a vehicle and its usage objective. Hence, the development of this wireless engine lubricant oil change alert system (Wi-LoCAS) in this research is fully controlled by microcontroller. The proposed system is capable of determining the total revolution experienced by the engine even at high revolution of the engine and able to predict a maximum lifetime supposed to be limited for the type of engine oil used by using the proposed oil change algorithm, $\text{MAXREV} = (1.2)\left(\frac{\text{highest gear ratio}}{\text{tire circumference}}\right) \times \text{distance travelled}$. The design was simulated using a microcontroller simulation package, Proteus 7 and its functionality was tested on a specially designed test rig. This system was also installed in two real cars to further validate its performance. The findings indicate that, this system is capable of predicting the engine lubricant lifetime precisely without being affected by the surrounding condition when the engine is operating.

ABSTRAK

Pelincir enjin memainkan peranan yang penting dalam mengurangkan geseran dalaman antara omboh dan ricih pada bahagian gerakan mekanikal. Selain itu, ia juga meningkatkan prestasi dan kecekapan enjin. Perkembangan pesat sistem pengawasan minyak pelincir enjin berlaku bagi menentukan tahap degradasi pelincir enjin untuk mengurangkan kehilangan kuasa enjin dan kos penyenggaraan. Walaubagaimanapun, ketepatan sistem pengawasan enjin sering terjejas oleh keadaan sekeliling seperti suhu, tekanan dan kandungan pelincir enjin manakala strategi menukar minyak-konvensional berpandukan jarak pergerakkan tidak sesuai kerana kadar degradasi minyak adalah berbeza berdasarkan jenis kenderaan dan objektif penggunaannya. Oleh itu, pembangunan sistem amaran ganti minyak pelincir enjin wayarles (Wi-LoCAS) dalam penyelidikan ini dikawal sepenuhnya oleh mikropengawal. Sistem yang dicadangkan ini berkebolehan untuk menentukan jumlah putaran yang dialami oleh enjin walaupun pada revolusi enjin yang tinggi dan mampu meramalkan hayat masimum yang patut dibataskan mengikut jenis minyak pelincir minyak yang digunakan dengan menggunakan algoritma penukaran minyak yang dicadangkan, $MAXREV = (1.2)\left(\frac{highest\ gear\ ratio}{tire\ circumference}\right) \times distance\ travelled.$ *Reka bentuk disimulasikan dengan menggunakan pakej simulasi mikropengawal, Protues 7 dan kefungsiaannya telah diuji dengan satu pelantar ujian yang direka khas. Sistem ini juga dipasang pada dua kereta dan seterusnya mengesahkan prestasinya. Keputusan menunjukkan bahawa sistem ini berkebolehan meramal hayat pelincir enjin dengan tepat tanpa terjejas oleh keadaan sekeliling ketika enjin sedang beroperasi.*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	-	Percentage
3D	-	Three Dimensional
AEOQ	-	Acoustic Engine Oil Quality
API	-	American Petroleum Institute
BAW	-	Bulk Acoustic Wave
BN	-	Base Number
DC	-	Direct Current
EC	-	Electrochemical
ECU	-	Engine Control Unit
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
EIA	-	Electronic Industries Association
FSS	-	Flexible Service System
GM	-	General Motor
GSM	-	Global System for Mobile Communication
HBr	-	Hydrogen Bromide
HCl	-	Hydrogen Chloride
ILSAC	-	International Lubricants Standardization and Approval Committee
IR	-	Infrared
ISE	-	Ion Selective Electrode
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MCU	-	Microcontroller
NO_x	-	Mono-Nitrogen Oxides
OEM	-	Original Equipment Manufacturer
PAO	-	Poly-Alpha-Olefins
PCB	-	Printed Circuit Board
PIO	-	Poly-Internal- Olefins

RFID	-	Radio Frequency Identification
RPM	-	Revolutions Per Minute
RuO_2	-	Ruthenium Oxide
SAE	-	Society of Automotive Engineers
SMS	-	Short Message Sending
SO_2	-	Sulphur Dioxide
TAN	-	Total Acid Number
TBN	-	Total Base Number
TF	-	Thick Film
TSM	-	Thickness Shear Mode
USART	-	Universal Synchronous/ Asynchronous Receiver Transmitter
VCO	-	Voltage Control Oscillator

LIST OF APPENDICES

LIST OF PUBLICATIONS

1. Sivarao, Samsudin, A.R., **Tin, S.L.**, Hasoalan, Taufik, Yuhazry, Abdul Alif, Robert, K.M., Sivakumard, and Tan, C.F., 2012. Promising Techniques of Automotive Engine Lubricant Oil Monitoring System – A Critical Review towards Enhancement. *The International Journal of Engineering and Science,* 1 (2), pp. 228-233. (DOAJ Indexed)

2. Sivarao, Samsudin, A.R., **Tin, S.L.**, Kassim, A.M., Taufik, and Amran, M.A., 2013. Programmable Automatic Service Time Reminder (PAST-R) To Overcome Traditional Mainteance Approach. *Australian Journal of Basic and Applied Sciences,* 7 (11), pp. 206-212. (SCOPUS Indexed)

3. Sivarao, Samsudin, A.R., **Tin, S.L.**, Kassim, A.M., Sivakumard, Ramli, R.A., and H'ng, Z.W., 2013. Pre-Setable Attendant Request Terminal (PART). CRLY000000769. (Coypright)

CHAPTER 1

INTRODUCTION

This chapter provides an introduction to the common problems faced by users with respect to the millage inaccuracy due to the inconsistency of lubricant oil degradation. This chapter consists of the problem statement, objectives, scope, and proposed solution to provide a better understanding of the entire project.

1.1 Background

Engine lubricant oil is a complex fluid which is manufactured to allow the engine performs perfectly and properly over a long service interval. In order to meet this goal, the lubricant is required to perform a variety of protective and functional jobs besides providing a hydrodynamic lubrication between moving components, including heat removing, suspending contaminants, neutralizing acid, preventing wear and tear and so on.

The engine lubricant oil life is defined as the change in fluid chemicals and physical properties while ultimately degrades during use. However, in recent years, the impact of inappropriate oil change intervals to the economy, environment as well as to car owners has received higher attention by major car manufacturers (Bommaredi, 2009). According to a news report from Utusan Malaysia's 8^{th} December 2011, improper engine maintenance had produced about 150 million litres of used lubricant oils (Idros, 2012). With increasing environmental and economic pressures, proper oil change intervals are deemed beneficial to environmental conditions and it also helps in the reduction of waste oil disposal or reclamation cost thus avoiding possible engine lubricant oil wastage (Bommaredi, 2009).

The typical engine lubricant oil can uphold between 5,000 km to 10,000 km mileage depending on the type of base oil used and the driving condition. Car manufacturers typically recommend that the engine lubricant oil should be replaced every 5,000 km or within duration of three months, whichever comes first. On the other hand, whenever the surrounding temperature are below freezing level, or either when mileage trips are short or in circumstances when prolong-idling occurs, it is categorized as severe condition.

A 10,000 km or six months oil-change interval is typically recommended when trips are long and when surrounding temperatures are mild. These criteria represent “normal” or “ideal” conditions. The oil replacement is necessary when it reaches the end of its functional status to maintain the engine protection. According to recommendations from lubricant oil manufacturers or vehicle original equipment manufacturers (OEMs), users usually change their engine lubricant oil at a constant interval, either based on time or mileage. However, since this oil changing common practice is not based on the real operating condition of the engine, the oil might be changed before reaching the end of its functional status or across its functional status. This would result in oil wastage and deemed uneconomical, besides further deteriorating the engine performance (Youngk, 2000).

With the reasons highlighted above, engine lubricant oil-change rate monitoring has become one of the largest areas of research, invention and innovation in the automobile industry. In the past century, various engine lubricant oil monitoring systems have been developed in accordance to the engine lubricant oil degradation. However, these systems are prone towards off-line detection and extraction of used oil sample besides introducing special detection mechanisms which are time-consuming and costly due to long monitoring cycles (Liu et al., 2009). Therefore, an automatic determination of the optimum oil-change point, based on the specific driving cycle of a given vehicle will benefit most drivers (Smolenski and Schwartz, 1987). The wireless engine lubricant oil change alert system provides excellent solution to the existing problems. This system is expected to trigger the user on the rate of lubricant oil change, whenever the oil approaches the end of its life - cycle in order to maintain the performance of the engine.

1.2 Problem Statement

Overused of engine lubricant oil will lead to degradation of engine performance. Besides, friction between the metal to metal surface increases engine seizes, as the overused engine lubricant oil lost its function to lubricate the moving parts in the engine (Simon and Michael, 2004). Hence, an increase in engine temperature is caused by the heat released from the friction. At the same time, additives in the oil namely detergents, dispersants, rust-fighters and friction reducers will induce wear out rate, therefore the oil will not lubricate as well as it should, causing the engine to wear and fail quickly (Hamid, 2012). Figure 1.1 illuminates the engine oil sludge, which is caused by engine lubricant oil overusing problem.

Figure 1.1 Engine Oil Sludge

The oil condition sensors have not yet been implemented as reliable oil-life monitoring systems for real time measurement of lubricant properties. For this to happen, signal processing of the sensors should be reliable and the response time needs to be low and extremely accurate. Laboratory based oil condition approaches have significant time lag and other logistical difficulties. Major concerns like sensor reliability to monitor the quality of oil, durability over long periods of operation, operational temperature range, survival at severe mechanical, chemical and thermal conditions, and functionality with different engines, oil grades and additives are yet to be addressed, without which the sensors cannot be used for oil life monitoring. Besides, the existing engine lubricant oil change alert system involve complicated algorithm in predicting engine lubricant change time (Bommaredi, 2009). The conventional oil-changing strategy according the mileage is not efficient as the rate of oil degradation is different based on the type of a vehicle and its usage objective (some vehicles can be frequently used in a highway, some vehicles can also be mainly used in an urban) affect degradation process of engine oil (Hong et. al, 2006).

1.3 Research Objective

The main objective of this project is to develop a new Wireless Engine Lubricant Oil Change Alert System (Wi-LoCAS) which can solve the problem related to overused engine lubricant oil. This project is conducted by the following procedures to:

a) Design a circuit for Wi-LoCAS to suit 4 cylinders internal combustion engine.

b) Develop and experimentally validate a new engine lubricant oil change algorithm.

c) Validate the performance of the developed Wi-LoCAS.

1.4 Research Scope

This research work relies within the scope of stated conditions:

a) Wi-LoCAS is designed to suit almost all types of internal combustion engine without taking into account of their respective engine capacity (cc).

b) The proposed oil change algorithm is limited to mechanical revolution.

c) Protues 7 simulation software and MikroC compiler is used for software and hardware design.

d) The designed system is most suitable to be integrated with engine ignition coil.

1.5 Thesis Organization

This thesis proposes an enhancement to the existing new wireless engine lubricant oil change alert system so as to tackle engine lubricant oil overuse problem. It consists of five chapters as follows.

Chapter 1 describes the introduction of the research and briefly explained the problem statements and objectives in the research. This chapter also included the scope and the outline of the research.

Chapter 2 presents a discussion on existing engine lubricant oil monitoring system. Along with this introduction, the issue of infeasibility of the existing approach and system is discussed. In the final section of this chapter, the proposed Wi-LoCAS specification and the proposed oil change algorithm is discussed.

Chapter 3 initiates the discussion on the development of the new Wi-LoCAS. The methods used to develop the proposed system are explained in detail in this chapter.

Chapter 4 performs and discuss experiment result. Besides, the reliability of the proposed oil change algorithm is validated and discussed in this chapter. Finally, chapter 5 presents a summary and a conclusion of this work, along with suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews critically of the engine oil function and characteristics, existing engine lubricant oil monitoring/alert systems and also gathered to have the broader knowledge of their framework and respective applications.

2.1 Engine Lubricant Oil

Engine lubricant oil (or engine oil in common) is a substance (usually a liquid) that is applied between two moving surfaces to reduce the friction between the surfaces as well as to improve efficiency and reduce wear. It also plays a role in dissolving or transporting foreign particles and distributing heat. Engine lubricant oil is mostly used to protect the internal combustion engines in motor vehicles and powered equipment. Most of the engine lubricant oils contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives. Besides that, vegetable oils or synthetic liquids such as hydrogenated polyolefin, esters, silicone, fluorocarbons and many others are sometimes used as base oils. Additives deliver reduced friction and wear, increased viscosity, improved viscosity index, resistance to corrosion and oxidation, aging or contamination (Pirrol and Wessol, 2001).