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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF FIBER OPTIC SENSOR FOR SEMI-SYNTHETIC ENGINE OIL PERFORMANCES WITH DIFFERENT CONCENTRATIONS

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Telecommunication) with Honours.

by

NURUL AMEERA BINTI ABDUL RAZAK

B071410526

950928-01-7176

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I hereby, declared this report entitled "Development of Fiber Optic Sensor for Semi-Synthetic Engine Oil Performances with Different Concentrations" is the results of my own research except as cited in references.

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Author's Name : NURUL AMEERA BINTI ABDUL RAZAK

Date : 18th JANUARY 2018

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 Electronic Engineering Technology (Telecommunications) with Honors. The member of the supervisory is as follow:

……………………………………………..

(Madam Rahaini Binti Md Said)

ABSTRAK

Gentian optik bukan sahaja digunakan dalam telekomunikasi, tetapi ia juga boleh digunakan dalam medium atau situasi lain. Sebagai contoh, aplikasi pemantauan jambatan, aplikasi pemantauan lembapan, aplikasi pemantauan retak dan lain-lain. Dalam kajian ini, sensor gentian optik telah digunakan dengan minyak enjin separuh sintetik dengan kepekatan yang berbeza, iaitu dari 10% hingga 100%. Ia adalah pembangunan baru untuk dilaksanakan dalam industri automotif. Sebelum meneruskan prototaip, beberapa data perlu dikumpulkan, iaitu merupakan sumber cahaya dan kehilangan kuasa di mana ia sebagai input dan output. Empat sumber cahaya yang berbeza iaitu 850nm, 1300nm, 1310nm dan 1550nm diuji. Hasilnya, 1300nm adalah sumber cahaya yang sesuai untuk dilaksanakan dalam medium ini kerana corak graf yang baik tetapi dengan sensitivity yang rendah. Sementara itu, 850nm dan 1310nm dikuasai sebagai kepekaan tertinggi tetapi tidak menunjukkan corak graf yang baik. Prinsip asas yang digunakan dalam kajian ini adalah jumlah pantulan dalaman.

ABSTRACT

Fiber optic is not only use in telecommunication, but it also can be applied in other mediums or situations. For example, the application of bridge monitoring, application of moisture monitoring, application of crack monitoring and else. In this research, the fiber optic sensor had been applied with semi-synthetic engine oil with different concentrations which is from 10% until 100%. It is new development to implement in the automotive industry. Before proceeds with the prototype, a few data need to be collect which is light source and power loss where it is as input and output. Four different light sources which is 850nm, 1300nm, 1310nm and 1550nm were tested. As a result, 1300nm was the suitable light source to implement in this medium due to good pattern graph but with the lowest sensitivity. Meanwhile, 850nm and 1310nm was dominantly used as the highest sensitivity but did not showed good pattern of graph. The basic principle used in this research was the amount of internal reflection.

DEDICATION

My effort was dedicated to beloved parents, family, lecturers and friends. I will remember for all their support, guidance and encouragement upon completing this project and report.

Special dedication to my parents

ABDUL RAZAK BIN BACHOK
SALINA BINTI SALLEH

ACKNOLEDEGEMENT

In the name of Allah S.W.T, the Most Gracious, who has given me a strength and ability to complete of this research. Praise to Him for seek help and guidance and under His benevolence we exist and without His help, this project could not be accomplished.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

FOS	–	Fiber Optic Sensor
ASE	–	Amplified Spontaneous Emission
OSA	–	Optical Spectrum Analyzer
EMI	–	Electromagnetic Interference
SMF	–	Single Mode Fiber
μ	–	Micro
mV	–	Milli Volts
T/bit	–	Terabit
dB	–	Decibel
COD		Coefficient of Determination

CHAPTER 1
INTRODUCTION

1.0 PROJECT BACKGROUND

Optoelectronics and fiber optic communications industries were two dominant items that had taken place over 20 years. The application that used in optoelectronic industry such as cameras, medical instrument, military applications and sun tracking solar panel. Then, fiber optic communications had changed the media communications industry by giving lofty implementation, more dependable telecommunication links with continually diminishing bandwidth cost. From the progressions was bringing the advantage of high-amount of manufacture to the users and a precise data constitute from glass. A line of these progression, fiber optic sensor innovation had a vast scale users of technology tie to optoelectronic and fiber optic communications industries. **(E. Udd,1991)**

Most of the parts associated with these industries were as often as can be produced for the utilization of fiber optic sensor. The success of fiber optic sensor technology and following extensive size of production to reinforce this business. The advantage of fiber optic was just not only their performances in telecommunication, but also can be implemented to monitor for anything and it is depending on the problem. Example of applications that can be used in fiber optic sensor are strain, temperature, velocity, vibration, dampness, chemical evaluation and else. **(E. Udd,1991)**

Benefits of optical fiber sensors can combine their ability to become lighter, small size, low power and passive resistance to electromagnetic interference, high sensitivity, bandwidth and extreme environments. Any benefit is lacking, where the price of fiber optic sensors is very expensive. **(E. Udd,1991)**

Semi-synthetic engine oil is a mixture of mineral oil and synthetic oil. Typically, not more than 30% synthetic oil with mineral oil. They are thinner and increase the productivity of the fuel in the engine. Semi-synthetic engine oil can be used for all types of engines. Moreover, the cost of a semi-synthetic engine oil is cheaper than fully synthetic motor oil. By using this oil, it can be assured that it offers the best performance and protection for all vehicles. Distance changes to semi-synthetic engine oil is between 5 000km to 10 000km. Therefore, to make the performance of engine be better and protect it from something that unexpected, the engine oil need to carry out by change according to a set time. If it fails to do so, problems will occur such as the friction and wear to the piston in the engine and also the performance of the car will be poor.

This project proposed to develop the semi- synthetic engine oil detection by using the fiber sensor. The optical fiber as a device that can be used to detect the different concentration for semi- synthetic engine oil.

1.1 PROBLEM STATEMENT

These days, there are various engine oil produced. Engine oil is the important things that need to be changed due to the increase of concentration. Semi-synthetic engine oil is a type of engine oil. Some people say that semi-synthetic engine oil should be changed when the trip has reached 5000 km, and there is also stated 10,000 km. That mean, the concentration of engine oil is affected by the distance travelled. As it is known, engine oil is used to move the engine components such as piston and ball bearings. For sure that users will not be able to predict the concentration of oil in the engine itself. They will follow a predetermined distance by a car. By applying fiber optic sensor, the concentration of engine oil will be able to be detect, and this is another alternative method or the right timing to change the engine oil.

1.2 OBJECTIVES

The main objectives of this project are:

a) To study fiber optic sensor operation.
b) To develop fiber optic sensor (FOS) for semi-synthetic engine oil performances with different concentration application.
c) To analyse the performance of fibre optic sensor (FOS) for concentration detection activity.

1.3 SCOPE

The scope of this project is applying single mode of fiber optic sensor to concentration of semi-synthetic engine oil detection in automotive industry. With the availability of this scope, it will make easy the process of experiment and as a right guideline to achieve the objectives.

CHAPTER 2
LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter, research has been done by others related to this study were discussed. Structural information is used to guide research in the right way. The source comes from books, journals and articles that have been written by previous researchers associated with this project. Theory and the results of this study can help them because they can be the difference between this and they seem.

2.1 FIBER OPTIC

2.1.1 INTRODUCTION TO FIBER OPTIC

Since in 1854, total internal reflection is known as a phenomenon where it is responsible for guide the light in optical fiber. Even though the glass fibers invented in 1920`s but it was practically used in 1950`s. The used of cladding layer was led to superior upgrade in their lead characteristic. Optical fiber looks much like monofilament fishing line. It is thin and transparent. Like metal electrical conductors, every fiber is a different substance, but many can have placed inside the same cable. Fiber optic communication widely utilized as a part of industrial communication system. This is due to optical fibers are non-conductors and light was not affected by electrical interference. **(Sterling,2004)**

2.1.2 STRUCTURE OF FIBER OPTIC

Core and cladding are two main concentric layers in optical fiber. The inner core is the light-carrying part. The surrounding cladding provides the difference in refractive index that allows total internal reflection of light through the core. The index of the cladding is less than 1 percent lower than that of the core. Typical values, for example, are a core index of 1.47 and a cladding index of 1.46. Fiber manufacturers must carefully control this difference to obtain desired fiber characteristics. **(Sterling,2004)**

By referred to **Figure 2.0**, fiber have an extra coating around the cladding. The coating, which is generally at least one or more layers of polymer, shield that core and cladding from shocks that might influence their optical or physical properties. The coating has no optical properties affecting the propagation of light within the fiber. This coating, then, is a shock absorber. **(Sterling,2004)**

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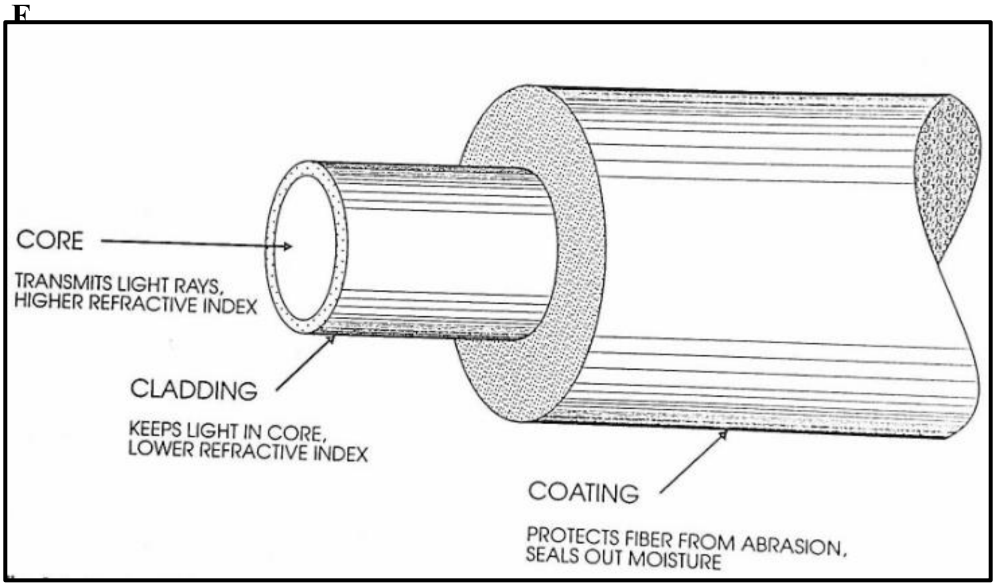

Figure 2.0: Typical Fiber Construction

Figure 2.1 shows the idea of light travelling through a fiber. Light injected into the fiber and striking the core-to-cladding interface at greater than the critical angle reflects into the core. Since the angles of incidence and reflection are equal, the reflected light will again be reflected. The light will continue zigzagging down the length of the fiber. **(Sterling,2004)**

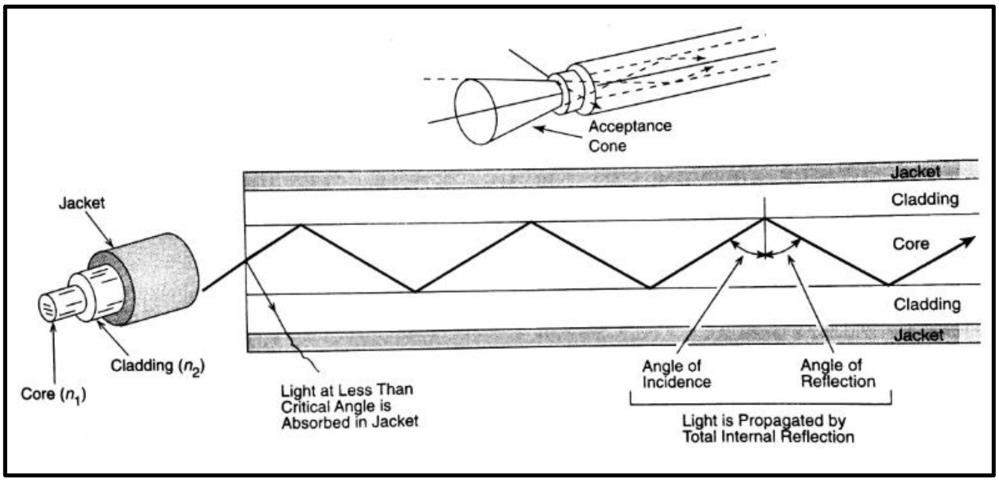

Figure 2.1: Total Internal Reflection in An Optical Fiber

Light, however, striking the interface at less than the critical angle passes into the cladding, where it is lost over distance. The cladding is usually inefficient as light carrier, and light in the cladding becomes attenuated rapidly. **(John`C.Huber, 1995)**

Notice also, in **Figure 2.1**, that the light is also refracted as it passes from air into the fiber. Thereafter, its propagation is governed by the indices of the core and cladding and by Snell`s law. **(John`C.Huber, 1995)**

Such total internal reflection forms of the basis of light propagation through a simple optical fiber. This analysis, however, considers only *meridional rays* – those that pass through the fiber axis each time they are reflected. Other rays, called *skew rays,* travel down the fiber without passing through the axis. The path of a skew rays is typically helical, wrapping around and around the central axis. Fortunately, skew rays are ignored in most fiber-optic analyses. **(Sterling,2004)**

Keep in mind that the fiber is circular. It can characterize a cone-also shown in **Figure 2.1**, that enters the core from within this acceptance cone will reflect down the fiber. Light outside the cone will not meet the more the core-to-cladding interface at an angle that allows total internal reflection. This light will not propagate. **(Sterling,2004)**

The specific characteristics of light propagation through a fiber depend on many factors, including:

a) The size of the fiber
b) The composition of the fiber
c) The light injected into the fiber

An understanding of the exchange between these properties will clear up many aspects of fiber optics. Fibers themselves have exceedingly small diameters. **Figure 2.2** shows cross sections of the core and cladding diameters of four commonly utilized fibers. The diameters of the core and cladding are shown as in **Figure 2.2. (Sterling,2004)**

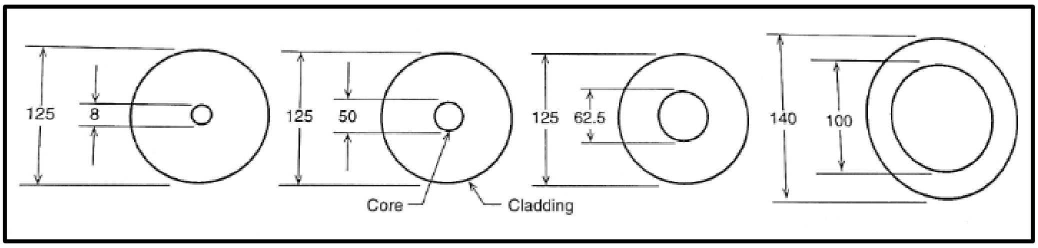

Figure 2.2: Typical Core and Cladding Diameters

Core (µm)	Cladding (µm)
8	125
50	125
62.5	125
100	140

Figure 2.3: The Measurement for Core and Cladding

2.1.3 FIBER CLASSIFICATION

Optical fibers are classified into two ways. One of their way is based on the material makeup: **(Sterling,2004)**

a) Glass fibers have glass core and glass cladding. The glass utilized as a part of strands is ultrapure, ultra-transparent silicon dioxide or fused quarts. If sea-water were as clear as a fiber, it could see to the bottom of the deepest ocean trench, the 35 839-foot-deep Marians Trench in the Pacific. Impurities are intentionally added to the pure glass to achieve the desired index of refraction. Germanium or phosphorus, for instance to increment the index. Meanwhile, the boron or fluorine are decrease the index. Other impurities not removed when the glass is purified also remain. These, as well, influence fiber properties by increasing attenuation by scattering or absorbing light.

b) Plastic-clad silica (PCS) fibers have a glass core and plastic cladding. Their performance is not good as all-glass fibers.

c) Plastic fibers have a plastic core and plastic cladding. Contrasted and different with other fibers, plastic fibers are limited in loss and bandwidth. Their very low cost and simple to utilize, however, make them attractive in applications where high bandwidth or low loss is not a concern. Their electromagnetic immunity and security enable plastic fibers to be usefully utilized. Plastic and PCS fibers don`t have buffer coating surrounding the cladding.

2.1.4 MODE

Mode is a mathematical and physical concept describing the propagation of electromagnetic waves through the media. In its mathematical form, mode theory derives from Maxwell`s equations. James Clerk Maxwell, a Scottish physicist in the last century, first gave mathematical expression to the relationship between electric and magnetic energy. He showed they were both form of electromagnetic energy, not two different forms as was then believed. His equation also showed that the propagation of this energy followed strict rules. Maxwell`s equations form the basis of the electromagnetic theory. **(Sterling,2004)**

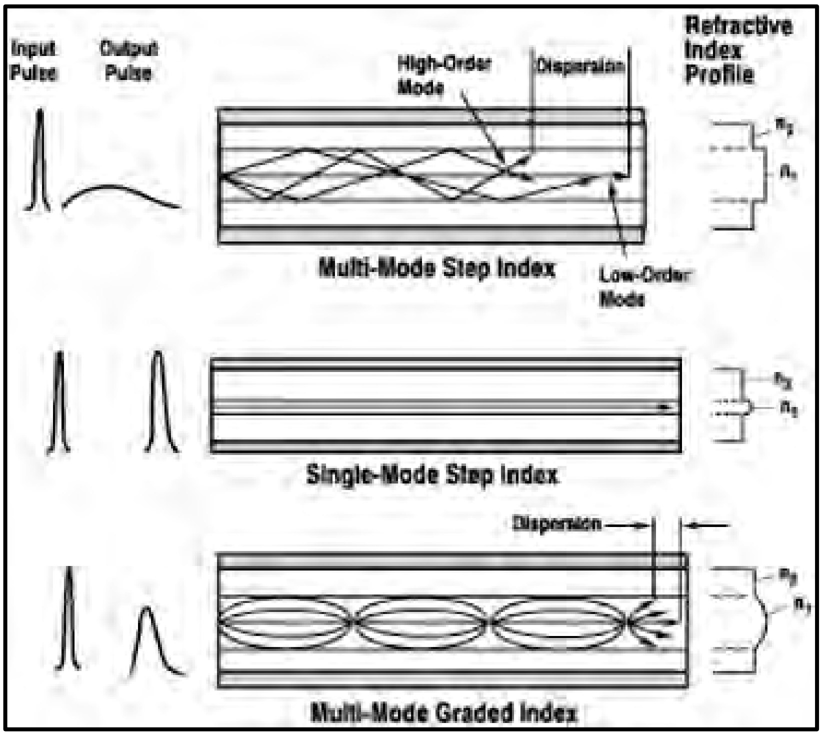

Figure 2.4: Types of Fiber Propagation

When the core of the fiber is small enough that only one ray can pass down the axis of the core, it is called single-mode fiber. A mode is path of light propagation. Therefore, when all light is in one path on the axis, there is but one single mode of propagation. On the other hand, when the core of the fiber is very large, many rays can pass down the core, at a variety of angles from the axis, up to the maximum angle for total internal reflection. A crude but effective analogy is that single-mode fiber acts like a rifle, with all the energy being in one projectile. **(John`C. Huber, 1995)**

Multimode fibers act like a shot gun, with the energy being spread out over many projectiles. Furthermore, like the bullet from a rifle, all the light in