UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIBER OPTIC SENSOR FOR CORN OIL CONCENTRATION DETECTION AND OPTIMIZATION PERFORMANCE USING ANALYSIS TECHNIQUE

This report submitted in accordance with requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor‟s Degrees in Electronic Engineering Technology (Telecommunications) 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 (Telecommunication) with Honours. The member of the supervisory is as follow:

……..

(Md Ashadi Bin Md Johari)

ABSTRACT

In the past two decades fiber optic technology has passed through many analytical stages. Commercially available fiber optic sensors are widely used in mechanical and industrial automation. They are also used in instrumentation and control. In the present work, this project is to analyze sensitivity of fiber optic sensor in determines the concentration of corn oil. Corn oil is used by replacing the petroleum because petroleum is rapidly depleting. Consequently, petroleum reserves are not sufficient enough to last many years. In this project, fiber optic are used to detect concentration because believe only right concentration can be used as fuel. But, difference of dilution would affect the result and the fiber optic sensors have proven can be a good sensor. Besides that, this project also can detect the difference dilution of corn oil to a fiber optic sensor. Through this project, faster transmission and high sensitivity of sensor will helps in increase the efficiency of the analysis of corn oil‟s concentration. This analysis may being useful technology to be used in corn oil and gas sector. The challenges of this project when to connect fiber optic sensor cable with pigtail cable because it is sensitive and easily frangible.

ABSTRAK

Dalam dua dekad teknologi gentian optik yang lalu telah melalui banyak peringkat analisis. Sensor gentian optik ini boleh didapati secara kormesial dan digunakan secara meluas dalam automasi mekanikal dan industsri. Ia juga digunakan dalam instrumentasi dan kawalan. Projek ini adalah untuk menganalisis sensitiviti sensor gentian optik dalam menentukan kepekatan minyak jagung. Minyak jagung digunakan dengan menggantikan petroleum kerana petroleum semakin berkurangan. Oleh itu, rizab petroleum tidak mencukupi untuk bertahan bertahun-tahun. Dalam projek ini, gentian optik digunakan untuk mengesan kepekatan kerana percaya hanya kepekatan yang betul boleh digunakan sebagai bahan api. Tetapi, perbezaan kecairan akan memberi kesan kepada hasil dan sensor gentian optik telah terbukti boleh menjadi sensor yang baik. Selain itu, projek ini juga dapat mengesan pencairan perbezaan minyak jagung untuk sensor gentian optik. Melalui projek ini, penghantaran cepat dan sensitiviti yang tinggi sensor akan membantu dalam peningkatan kecekapan analisis kepekatan minyak jagung itu. Analisis ini boleh menjadi teknologi yang berguna untuk digunakan dalam minyak jagung dan sektor gas. Antara cabaran dalam projek ini penyambungan kabel gentian optik sensor dengan kabel pigtail kerana ia amat sensitif dan mudah patah.

... Dedicated to...

My beloved Father and Mother

Zaine Bin Bakar and Jameah Binti Hashim

My sisters and Family

Thank You from the Bottom of My Heart for Being My Inspirations

And Lastly to All My Dear Friends

Thank You for Supporting Me

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LIST OF SYMBOLS AND ABBREVIATIONS

POF	Plastic Optical Fibre
NA	Numerical Aperture
SPR	Surface Plasmon Resonance
TM	Transverse Magnetic
FST	Fluorescence Signal Transmission
EST	Electrochemical Signal Transduction
TIR	Total Internal Reflection
PPM	Parts Per Million
ASE	Amplified Spontaneous Emission
OSA	Optical Spectrum Analyser

CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, speed of data transmission is being given a prior for human being to perform well in their specific field of task. Speed of data transmitted is being concerned especially for engines and communication, where it helps human being to perform well in their life. Fiber has become communications medium of choice for telephones, cell phones, LAN backbone, security cameras, industrial networks, just about every kind of communication. The biggest advantage of optical fiber is the fact it is the most cost effective means of transporting information. Fiber can transport more information longer distances in less time than any other communication medium. The bandwidth and distance capability of fiber means that fewer cables, fewer repeaters, less power and less maintenance are needed. In addition, fiber is unaffected by the interference of electromagnetic radiation which makes it possible to transmit information and data with less noise and less error.

Other than that, easy realization and better sensitivity make fiber optic sensor is a better choice compared to traditional copper cables. The fiber optic sensor is very promising area for commercial applications due to cost effectiveness, easy realization, sensitivity and small in size. In view of the advantages, fiber optic sensors have become very popular in the areas like process control, avionics, petrochemical and pharmaceutical.

Next, corn oil is oil extracted from the germ of corn. Its main use is in cooking, where its high smoke point makes refined corn oil valuable frying oil. Corn oil is also a feedstock used for biodiesel. Other industrial uses for corn oil include soap, salve, paint, rust proofing for metal surfaces, inks, textiles and insecticides. It is sometimes used as a carrier for drug molecules in pharmaceutical preparations.

However, this project is to analyze sensitivity of fiber optic sensor in determine the concentration of corn oil. This corn oil will used by replacing petroleum. Other than that, fiber are used to detect concentration because believe only right concentration can be used as a fuel. But, difference of dilution would affect the result and the fiber optic sensors have proven can be a good sensor. So, this project is to develop a fiber optic sensor for detecting the difference dilution of corn oil. Faster transmission and higher sensitivity of the sensor helps in increase the efficiency of the analysis of corn oil‟s concentration. This analysis may being a useful technology to be used in oil and gas sector.

In addition, this project also use analysis technique which a process of inspecting, cleaning, transforming, and modeling data with the goal of discovering useful information, suggestion conclusion, supporting decision making. This technique is a method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output.

1.2 Problem Statement

In Malaysia, the petroleum was diminishing and need to be replacing with biodiesel. So, in this project the corn oil are used to replace the biodiesel. The fiber are used to detect concentration because believe only the right concentration can be used as fuel. The corn oil is used to turn on the engine but the engine is not able to function only by using corn oil. However, in corn oil contains hydrogen and hydrogen need to be

broken down by other material such as Hexene. Hexene is an organic compound with the formula C_6H_{12}. It is an alkene that is classified in industry as higher olefin and alpha-olefin, the latter term meaning that the double bond is located at the alpha (primary) position, endowing the compound with the higher reactivity and thus useful chemical properties. This Hexene are needed to turn on the engine. In addition, Hexene are used to make the corn oil was suitable for the engine. Hexene can‟t be included directly because it has the concentrations. So, this corn oil and Hexene influence the result for optical fibers. For example, how many percent corn oil and Hexene was needed and it will affect the result for optical fibers.

1.3 Project Objectives

There are three main objectives in this study which lead to project success. The objective of the project is to;

1. To understand fiber optic communication.
2. To develop fiber optic sensor.
3. To analyze the performance of fiber optic sensor in identifying the concentration of corn oil.

1.4 Project Scope

In order to achieve the objective of the study, the scope has been outlined. There are two parts in this project which are Project Sarjana Muda I for the first semester and Project Sarjana Muda II for second semester. By the first semester, includes literature review and methodology which more related about the project research and concept of fiber optic sensor. Next, for the second semester will focus on experiment result and discussion.

The scope of study includes:

1. Understanding of fiber optic sensor and properties.
2. Design fiber optic to be used as a sensor.
3. Understanding the effects of the use of corn oil on the fiber optic.
4. Calculate the output losses in decibel (dB).

CHAPTER 2

THEORETICAL BACKGROUND

2.1 Introduction

This section present about theoretical background. Before design the fiber optic sensor for corn oil, concentration detection and optimization, need to understand the concept of fiber optic and how it works. The concept of fiber optic is described in more detail. Addition, the previous research based on fiber optic sensor, corn oil and light sources included on this chapter.

2.2 Fiber Optics

In **Figure 2.1** illustrate about fiber optic and refers to the technology of transmitting light down thin strands of highly transparent optical fibers, usually glass but sometimes plastic. Fiber optics is used in communications, lighting, medicine, optical inspections and to make sensors. A fiber optic communications means sending signals from one location to another in the form of modulated light guided through hair-thin fibers of glass or plastic. These signals can be analog or digital and voice, data, or video. Fiber can transport more information longer distances in less time than any copper wire

or wireless method. It‟s powerful and very fast-offering more bandwidth capability than any other form of communication. [Hayes J., 2009]

Figure 2.1: Fiber Optic Cable

2.3 Fiber Optic Cable Construction

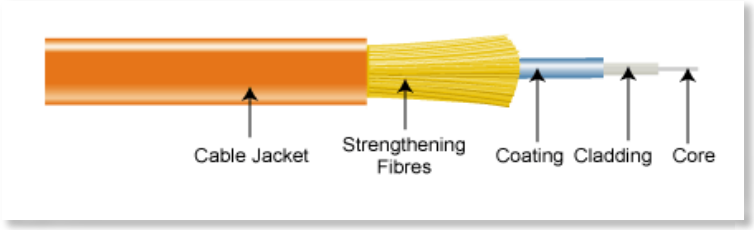

Figure 2.2: Fiber Optic Cable Construction

Figure 2.2 showed the fiber optic cable construction. There are few materials that using in element in fiber optic cable such as cable jacket, strengthening fibers, coating, cladding and core. Every single element in fiber optic cable has its own function. A core is the physical medium that transports optical data signals from an attached light source to a receiving device. The core is a single continuous strand of

glass or plastic that‟s measured in micron (μ) by the size of its outer diameter. The larger the core, the more light the cable can carry. For cladding it is thin layer that surrounds the fiber core and serves as a boundary that contains the light waves and causes the refraction, enabling data to travel throughout the length of the fiber segment. Next, coating is a layer of plastic that surrounds the core and cladding to reinforce and protect the fiber core. The strengthening fibers help protect the core against crushing forces. Last but not least, the cable jacket is the outer layer of any cable. Most fiber optical cables have an orange jacket, although some types can have black or yellow jackets.

2.4 Types of Fiber Optic

There are two basic types of fiber: multimode fiber and single-mode fiber. Multimode fiber is best designed for short transmission distances, and is suited for use in LAN systems and video surveillance. Single-mode fiber is best designed for longer transmission distances, making it suitable for long-distance telephony and multichannel television broadcast systems.

2.4.1 Multimode Fiber

Multimode fiber has light travelling in the core in many rays, called modes. It has larger core (almost always 50 or 62.5 microns) which supports the transmission of multiple modes (rays) of light. Multimode is generally used with LED sources at wavelengths of 850 and 1300 nm. Multimode fiber may be categorized as step-index or graded-index fiber.

For the step-index multimode fiber was the first design. The core of step index multimode fiber is made completely of one types of optical material and the cladding is another type with different optical characteristic. It has higher attenuation and is too slow for many uses, due to the dispersion caused by the different path lengths of the various modes travelling in the core. Step index fiber is not widely used- only POF and PCS/HCS (plastic or hard clad silica, plastic cladding on a glass core) use a step index design today. POF mainly used for consumer audio and TV links.

Next for the Graded index multimode fiber uses variations in the composition of the glass in the core to compensate for the different path lengths of the modes. It offers hundreds of times more bandwidth than step index fiber-up to about 2 gigahertz. Two types are in use, 50/125 and 62.5/125, where the numbers represent the core/cladding diameter in microns. Graded index multimode fiber is primarily used for premises networks, LANs, fiber to the desk, CCTV and other security systems. [Hayes J., 2009]

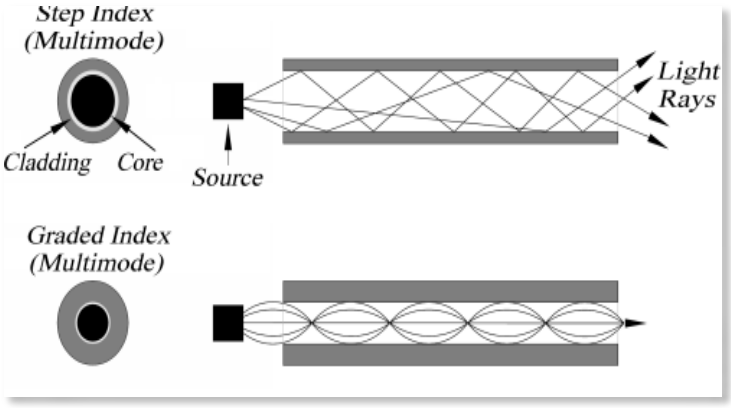

Figure 2.3: Multimode Step Index Fiber and Multimode Graded Index Fiber

2.4.2 Single Mode Fiber

Single mode fiber has a much smaller core, only about 9 microns, so that the light travels in only one ray (mode). It is used for telephony and CATV with laser sources at 1300 and 1550 nm because it has lower loss and virtually infinite bandwidth. Single mode fiber is use for outside plant networks such as telco, CATV, municipal networks and long data links such as utility grid management. [Hayes J., 2009]

Figure 2.4: Single Mode Fiber

2.4.3 Plastic Optical Fiber (POF)

Plastic Optical Fiber (POF) is large core (about 1mm) fiber, usually step index that is used for short, low speed networks. PCS/HCS (plastic or hard clad silica, plastic cladding on a glass core) has a smaller glass core (around 200 microns) and a thin plastic cladding [H. Jim, 2009]. Thus, there is reduced requirement for a buffer jacket for fiber protection and strengthening. These fibers are better than the corresponding silica based glass variety because they are usually cheaper to produce and easier to handle. However, they have limited use in communication applications as their performance especially for optical transmission in the infrared restricted. POF have large numerical apertures which are multimode with either step or graded index profile as a consequence of the core cladding refractive index difference which allow easier coupling of light into the fiber from a multimode source.

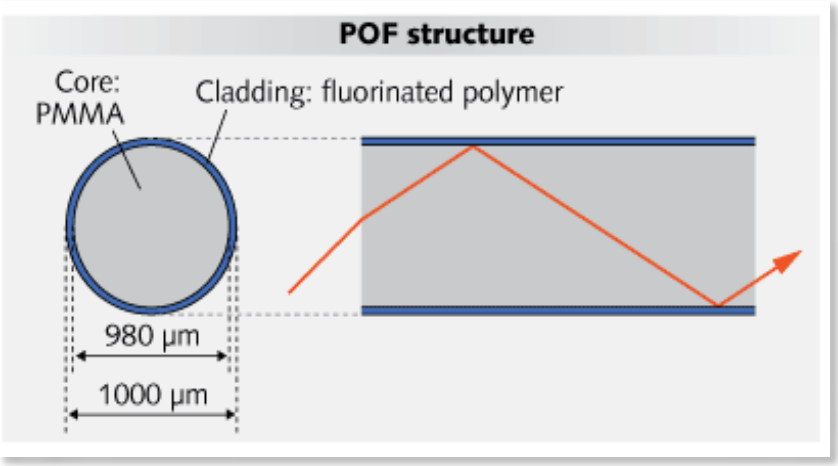

Figure 2.5: Typical Structure for POF