UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIBER OPTIC SENSOR FOR PALM OIL DETECTION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Electronic Engineering Technology (Telecommunications) with Honours

by

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TAJUK: **Fiber Optic Sensor for Palm Oil Detection**

SESI PENGAJIAN: **2015/16 Semester 2**

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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 (Type your department's name here) (Hons.). The member of the supervisory is as follow:

……………………………………………

(Mr. Md Ashadi Bin Md Johari)

ABSTRACT

50 years ago, sensor fibre optics had become one of the most successful and most most powerful application for both optic fiber and also technology for sensor. Recently, with rapid expansion in micro or nano technology have increased request that is high in fiber optic sensor. With higher performance and versatility, space utilisation that is small also is one of the current trends for optic fiber sensor. This project to analyze power measurement value in palm oil concentration that is different and using this fiber optic detector is to know which detector over detector sensitivity. This analysis may be useful for technology in oil and industrial gas.

ABSTRAK

Pada 50 tahun lepas, serat optik penderia telah menjadi salah satu permohonan paling berjaya dan paling berkuasa untuk kedua-dua fiber optik dan juga teknologi untuk penderia. Baru-baru ini, dengan perkembangan pesat di mikro atau teknologi nano telah meningkat permintaan yang tinggi di penderia gentian optik. Dengan prestasi lebih tinggi dan keserbabolehan, penggunaan ruang yang kecil juga ialah salah satu trend-trend semasa untuk penderia fiber optik. Projek ini untuk menganalisis nilai pengukuran kuasa di dalam kepekatan minyak sawit yang berbeza dan menggunakan alat pengesan gentian optik ini adalah untuk mengetahui alat pengesan mana yang lebih sensitiviti alat pengesan. Analisis ini mungkin berguna bagi teknologi dalam minyak dan gas perindustrian.

DEDICATIONS

This humble effort specially dedicated to my beloved parents, family, lecturers and friends, whose love can never be forgotten for their support, guidance and encouragement upon completing this project and report.

Special dedicated to my family

MOHD NAWI BIN UMAR

JUHASWITA BINTI JUNOH

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

In the past 50 years, fiber-optical sensing has been one of the most successful and powerful applications of both fiber optics and sensing technology [Spillman, 2001]. Fiber optic sensing is facilitated by its salient features, which make it prominent among other sensing methods. These fiber optic sensors successfully meet the requirements like high sensitivity and quick response in sensing different chemical and physical variables. Using optical fiber sensing devices one can measure or monitor different physical and chemical parameters in terms of one of the principal parameters that describes the light beams. These principal parameters include light intensity, phase, polarization and wavelength. The characteristic features and promising capabilities of fiber optic sensors make them attractive and place them in the forefront of the Photonics technology. In the fiber optic sensing system, the sensed signal is immune to electromagnetic interference (EMI) and radio frequency interference (RFI). Since optical fibers offer low loss to the signal propagating through it we can use this method for remote sensing applications.

After the energy crisis in the mid 1970s, every country has tried to find a new energy that can replace petroleum by using their district energy; specifically, vegetable oil, the most promising alternative fuels. Vegetable oils cannot be used directly in diesel engines because of the problem associated with it of the using pure vegetable oils as fuels in diesel engines. There are more than 350 oil bearing crops identified, among which only sunflower, soybean, cottonseed, rapeseed and peanut oils are considered as potential alternative fuels for diesel engines [C. Charoenphonphanich, 2004]. The most detrimental properties of these oils are their high viscosity, low volatility, poor atomization and auto-oxidation [C. Y. May, 2005].

Recently considerable attention in developing countries such as Malaysia, Indonesia and Thailand has been drawn to the production of bio-fuels from domestic, renewable resources. Bio-fuels are currently being considered from multidimensional perspectives, i.e. depleting fossil fuels, resources, environmental health, energy, security and agricultural economy. The two most common types of bio-fuels are ethanol and bio-diesel [A. A. Aziz, 2006]. Chiyuki and Jun-ichi (1998) concluded that de-acidified rapeseed oil could be used in a single cylinder Yanmar IDI diesel engine but degummed and crude rapeseed oil were unsuitable for use as fuel due to the high level of incombustible materials in the oil. Suporn (1987) found that using 100% refined palm oil in a Kubota diesel engine model KND 5B resulted in the best power output and best emission while using 70% refined palm oil blended with 25% diesel resulted in the best specific fuel consumption [T. Apichato, 2003]. For vehicles powered with diesel engines, an alternative substitute of diesel fuel has been developed namely, biodiesel. It is produced from the chemical bonding of an alcohol with oils, fats, greases or chemically known alkyl esters [R. Zanzi, 2006]. These esters have similar properties as the mineral diesel fuel and even better in terms of its cetane number. In addition, biodiesel is better than diesel fuel in terms of sulfur content, flash point and aromatic content [C. Y. May, 2005]. As a liquid fuel, biodiesel is simple to use and can be used in compression ignition (diesel) engines without modifications. It also can be blended at any level with petroleum diesel to create a biodiesel blend [A. Aziz, 2005]. Regarding these qualities of vegetable oils, Malaysia has committed to investigate the use of biodiesel with blends of palm oil as an alternative fuel for diesel engines. This paper presents palm biodiesel as an alternative green renewable bio-fuel for diesel engines.

This project is about to develop the palm oil concentration detection using the fiber sensor. The main part is the functional of optical fiber in telecommunication system. The optical fiber can use to detect the concentration of palm oil using the high-index of oil.

1.2 OBJECTIVE

The main objective of this project:

- **a.** To study fiber optical sensor for palm oil concentration detection.
- **b.** To development fiber optical sensor for palm oil concentration detection.
- **c.** To analyze the performance of fiber optic sensor for concentration detection activity.

1.3 PROBLEM STATEMENT

Nowadays, the use biomass as an energy source should be part of the climate change solution as long as it is developed in a truly sustainable way. The problem occur in our world is the production of biodiesel or bio-fuels are decrease. The biochemistry makes research and analysis to find new liquor fuels to replace biodiesel using biomass. Palm oil is now starting to be used as an ingredient in bio-diesel and as a fuel to be burnt in power stations to produce electricity. This project is implementation using the application of fiber optical sensor to detect the concentration of palm oil. Reason why we must detect different concentration? This is because very different power value in every concentration for performance of palm oil biodiesel as bio-fuel energy.

1.4 SCOPE

The scope of this project is to study and develop fiber optical sensor for palm oil concentration detection. This project to ensure the project is heading in the right direction to achieve its objective. The scopes of this project are to study and develop the Fiber Optical Sensor, Fiber Optical Sensor for Liquor and also Concentration of Palm Oil.

1.5 LIMITATION

The limitations of the study are those characteristics of design or methodology that impacted or influenced the interpretation of the findings from a research. They are the constraints on generalize ability, applications to practice, and/or utility of findings that are the result of the ways in which there initially chose to design the study and/or the method used to establish internal and external validity. Some of limitations are:

a. Fiber optical sensor is going too used.
b. Sensor can detect the palm oils.

CHAPTER 2

THEORETICAL BAKGROUND

2.1 FIBER OPTICAL & FIBER OPTICAL SENSOR

2.1.1 Optical Fiber Basics

An optical fiber is composed of three parts; the core, the cladding, and the coating or buffer. The basic structure is shown in **Figure 2.1**. The core is a cylindrical rod of dielectric material and is generally made of glass. Light propagates mainly along the core of the fiber [Jones, 1998].

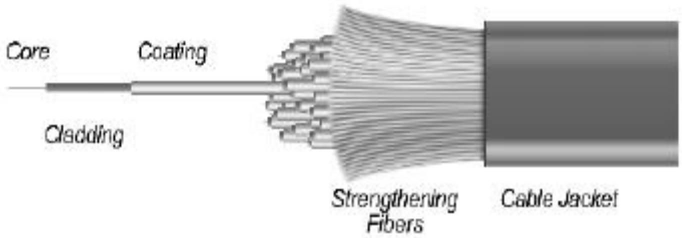

Figure 2.1: Basic structure of an optical fiber.

The cladding layer is made of a dielectric material with an index of refraction. The index of refraction of the cladding material is less than that of the core material. The cladding is generally made of glass or plastic. The cladding executes such functions as decreasing loss of light from core into the surrounding air, decreasing scattering loss at the surface of the core, protecting the fiber from absorbing the surface contaminants and adding mechanical strength [Jones, 1998].

The coating or buffer is a layer of material used to protect an optical fiber from physical damage. The material used for a buffer is a type of plastic. The buffer is elastic in nature and prevents abrasions [Jones, 1998]. The light-guiding principle along the fiber is based on the “total internal reflection”. The angle at which total internal reflection occurs is called the critical angle of incidence. At any angle of incidence, greater than the critical angle, light is totally reflected back into the glass medium (see **Figure 2.2**). The critical angle of incidence is determined by using Snell's Law. Optical fiber is an example of electromagnetic surface waveguide [Jones, 1998].

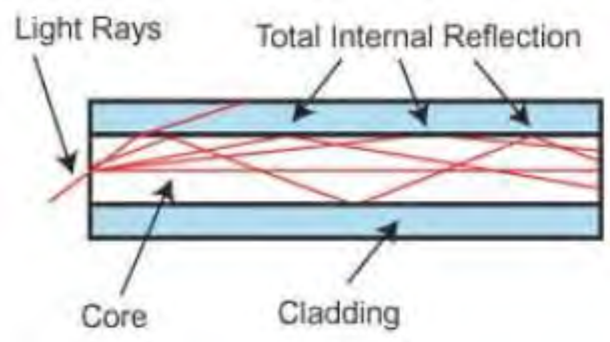

Figure 2.2: Total internal reflection in an optical fiber.

Optical fibers are divided into two groups called single mode and multimode. In classifying the index of refraction profile, we differentiate between step index and gradient index. Step index fibers have a constant index profile over the whole cross section. Gradient index fibers have a nonlinear, rotationally symmetric index profile, which falls off from the center of the fiber outwards [Jenny, 2005]. **Figure 2.3** shows the different types of fibers.

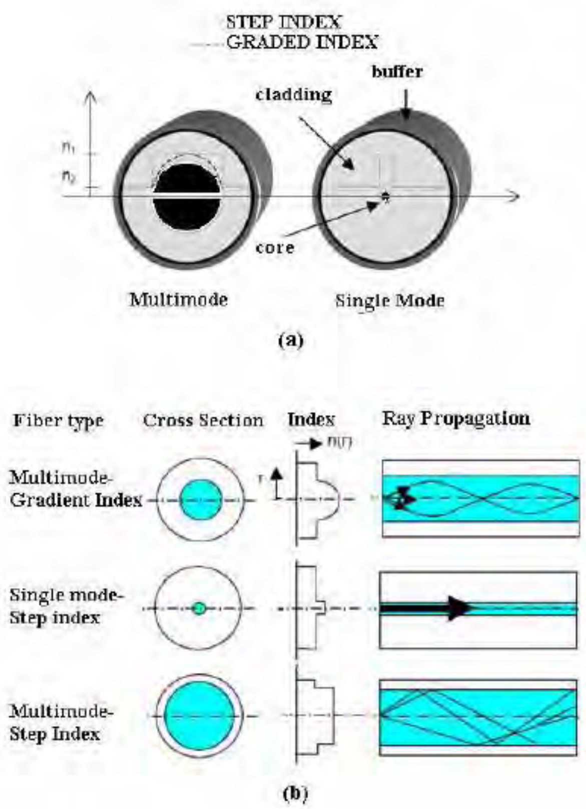

Figure 2.3: Different types of optical fibers.

2.1.2 Fiber Optic Sensor Principles

The general structure of an optical fiber sensor system is shown in **Figure 2.4**. It consists of an optical source (Laser, LED, Laser diode etc), optical fiber, sensing or modulator element (which transducers the measured to an optical signal), an optical detector and processing electronics (oscilloscope, optical spectrum analyzer etc.).

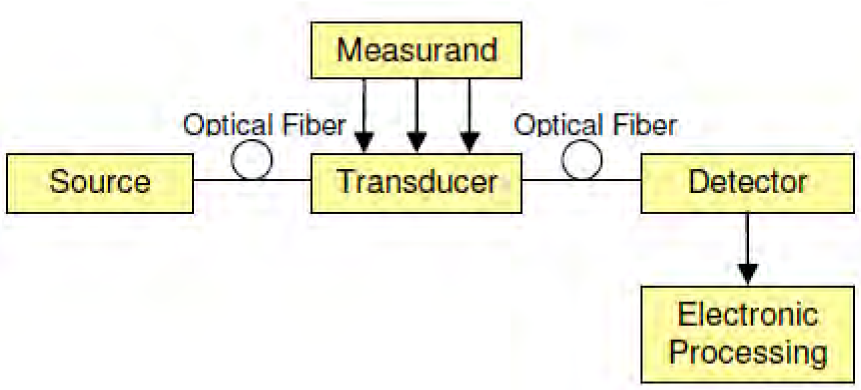

Figure 2.4: Basic components of an optical fiber sensor system.

Fiber optic sensors can be classified under three categories: The sensing location, the operating principle, and the application. Based on the sensing location, a fiber optic sensor can be classified as extrinsic or intrinsic. In an extrinsic fiber optic sensor (see **Figure 2.5**), the fiber is simply used to carry light to and from an external optical device where the sensing takes place. In these cases, the fiber just acts as a means of getting the light to the sensing location.

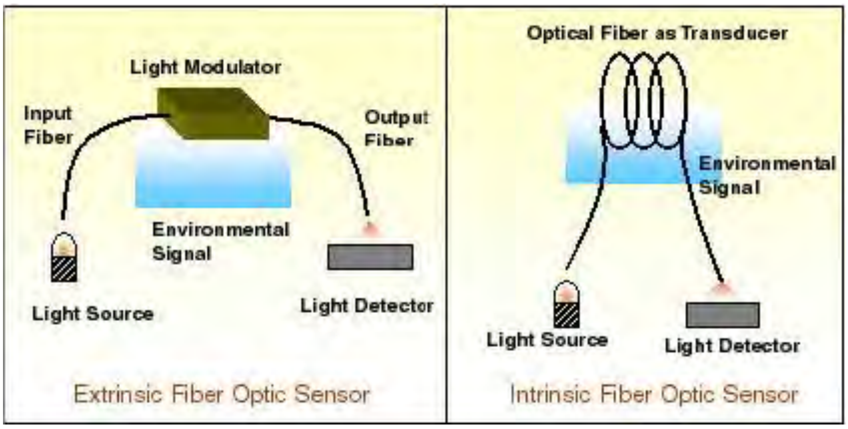

Figure 2.5: Extrinsic and intrinsic types of fiber optic sensors.

On the other hand, in an intrinsic fiber optic sensor one or more of the physical properties of the fiber undergo a change (see **Figure 2.5**). Perturbations act on the fiber and the fiber in turn changes some characteristic of the light inside the fiber [Tracey, 1991].

Based on the operating principle or modulation and demodulation process, a fiber optic sensor can be classified as intensity, a phase, a frequency, or a polarization sensor. All these parameters may be subject to change due to external perturbations. Thus, by detecting these parameters and their changes, the external perturbations can be sensed [Yu, 2002]. Based on the application, a fiber optic sensor can be classified as follows:

- Physical sensors: Used to measure physical properties like temperature, stress, etc.
- Chemical sensors: Used for pH measurement, gas analysis, spectroscopic studies, etc.
- Bio-medical sensors: Used in bio-medical applications like measurement of blood flow, glucose content etc.

2.2 BIODIESEL

2.2.1 Overview

Biodiesel has a major advantage over petroleum diesel, since, it is derived from renewable sources it is a clean burning fuel that does not contribute to the increase of carbon dioxide, being environmentally friendly [S. L. Cheah, 2004]. Biodiesel is an oxygenate, sulphur-free and biodegradable fuel, and its content of oxygen helps improve its combustion efficiency Therefore, fewer green house gases such as carbon dioxide are released into the atmosphere. Biodiesel has positive performance attributes such as increased cetane, high fuel lubricity, and high oxygen content [A. Aziz, 2005]. Since, biodiesel is more lubricating than diesel fuel, it increases engine life and it can be used to replace sulphur, a lubricating agent, that when burned, produces sulphur oxide; the primary component in acid rain.

2.2.2 Transesterification Process

Biodiesel is a very versatile transport fuel and can be produced from local raw material or collection of used vegetable or frying oil in rural regions of developing countries. There are three basic routes to biodiesel production from oils and fats [R. Ranzi, 2006]:

- Base catalyzed transesterification of the oil
- Direct acid catalyzed transesterification of the oil
- Conversion of oil to its fatty acids and then to biodiesel

Transesterification reaction is a stage of converting oil or fat into methyl or ethyl esters of fatty acid, which constitutes to biodiesel. Biodiesel (methyl ester) is obtained through the reaction of triglycerides of vegetable oils with an active intermediary, formed by the reaction of an alcohol with a catalyst. The general reaction for obtaining biodiesel through transesterification is [U. H. Bezerra, 2007]:

Oil or Fat + ***Methanol*** ⟶ ***Methyl Esters*** +***Glycerol***

Or

Oil or Fat + ***Methanol*** ⟶ ***Ethyl Esters*** +***Glycerol***

Transesterification reactions may employ various types of alcohols, preferably, those with low molecular weight, with the most studied ones being the methylated and ethylated alcohols. Studies have shown that transesterification with methanol is more viable technically than with ethanol. Ethanol may be used as long as it is anhydrous (with a water content of less than 2%), since the water acts as an inhibitor reaction. Another advantage in using methanol is the separation of glycerin (obtained as a by-product of the reaction) from the reactive medium, since, in the case of synthesis of the methylated ester, this separation may be easily obtained through simple decantation [U. H. Bezerra, 2007]. **Figure 2.6** illustrates the simplest procedure of manufacturing biodiesel through transesterification with vegetable oil.