UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FIBER OPTIC SENSOR FOR OLIVE OIL CONCENTRATION MEASUREMENT AND OPTIMIZATION OF SENSOR PERFORMANCE

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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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for Bachelor of Electronic Engineering Technology (Telecommunication) with honors. The member of the supervisory is as follow:

………………………………………………

(Mr. Md Ashadi Bin Md Johari)

ABSTRACT

Fiber optic was widely used in communication because of their permit transmission over longer distances and higher bandwidth data rates than wire cables. Fiber optic cable transfer data rates as high as 111 gigabits per second. Fiber optic cable has three types. There are multimode step-index, multimode graded index and single mode. For fiber optic sensor it is a sensor that used optical fiber as the sensing element which means of relaying signals from a remote sensor to the electronics that process the signals. It also immune to electromagnetic interference and do not conduct electricity, so it can be placed in high voltage or flammable area. his project is to analyze the sensitivity of the fiber optic sensor for determining the concentration of olive oil with different search . This analysis may be useful to technology in the oil and gas sector.

ABSTRAK

Gentian optik telah digunakan secara meluas dalam komunikasi kerana penghantaran permit mereka pada jarak yang lebih panjang dan kadar data lebar jalur lebih tinggi daripada kabel wayar. Serat optik kadar pemindahan data kabel setinggi 111 gigabit sesaat. Kabel gentian optik mempunyai tiga jenis. Terdapat mod langkah - indeks, mod digredkan indeks dan mod tunggal. Untuk serat sensor optik ia adalah sensor yang menggunakan gentian optik sebagai unsur penderiaan yang bermakna bagi menyampaikan isyarat daripada sensor jauh untuk elektronik yang memproses isyarat . Ia juga kebal terhadap gangguan elektromagnet dan tidak mengalirkan elektrik , jadi ia boleh diletakkan dalam voltan tinggi atau kawasan mudah terbakar. projek ialah untuk menganalisis kepekaan sensor gentian optik untuk menentukan kepekatan minyak zaitun dengan carian yang berbeza. Analisis ini mungkin berguna untuk teknologi dalam sektor minyak dan gas.

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.

ACKNOWLEDGEMENTS

In the name of Allah S.W.T, The most Merciful and The most Passionate, I am thankful to Allah for enabling me to complete this report.

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Last but not least, I would like to thanks for those who are directly or indirectly involved during completion of this project. All of your kindness are very much appreciated.

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LIST OF SYMBOLS AND ABBREVIATIONS

SBM	**=**	**Shape-Based Matching**
MSM	=	Multimode-single mode-multimode
MMF	=	Multimode fibers
SMF	=	Singlemode fibers
FBG	=	Fiber Bragg Grating
LPGs	=	Long Period Grating
DBR	=	Distributed Bragg Reflector
DFB	=	Distributed Feedback Bragg
LLS	=	Liquid Level Sensor
TM	=	Transverse Magnetic
MOFs	=	Microstructured Optical Fiber
dB	=	Decibels
ASE	=	Amplified Spontaneous Emission
OSA	=	Optical Spectrum Analyzer

CHAPTER 1

INTRODUCTION

1.0 Introduction

Fiber optic cables is well known can transmit data fast and also carry more data than metal cable. In this chapter, it will discuss about the project background. It also consists the problem statement, the objective of this project and the scope of this project.

1.1 Background

Nowadays, fiber optic became the best technology that uses glass (or plastic) threads (fibers) to transmit data. A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves. Fiber optic has several advantages from metal communication. There are, fiber optic cables have a much greater bandwidth than metal cables. This is means that its can carry more data. A fiber optic cable also less susceptible to interference and it's also much thinner and lighter than metal cables. Data from fiber optic can be transmitted digitally (the natural form computer data) rather than analogically. Unfortunately, fiber optic has the main advantages. There are, the cables are expensive to install. In addition, they are more fragile than wire and are difficult to splice.

A fiber optic sensor is a sensor that uses optical fiber. It also immune to electromagnetic interfaces, and do not conduct electricity. A fiber optic sensor also ideal for harsh conditions such as in high vibration, extreme heat, noisy, wet, corrosive or explosive environments. It also has small size to fit in confined areas and can be positioned precisely where needed with flexible fibers.

Olive oil is a fat obtained from the olive (the fruit of Olea europaea; family Oleaceae), a traditional tree crop of the Mediterranean Basin. The oil is produced by pressing whole olives and is commonly used in cooking, cosmetics, pharmaceuticals, and soaps, and as a fuel for traditional oil lamps. Olive oil is used throughout the world and is often associated with Mediterranean countries. The beneficial effects of consuming olive oil are backed by lengthy, painstaking scientific research. Fats and oils have a common denominator in the energy value (9 calories per gram) but the metabolism of each different group differs greatly from the rest. Olive oil contains a series of compounds that are very beneficial to most functions of the human body and its' biological and therapeutic value is related in many aspects to its chemical structure.

1.2 Problem Statement

Currently, health becomes the first list for mankind. In order to get health, human has to always check fat and cholesterol in their food. It has two ways either do some exercise or control nutrition. Olive oil is believed to reduce some fat in human body. But, it has its own concentration to reduce fat. Olive oil is a healthier option than butter as olive oil contains only 33% saturated fat while butter is composed of 66% saturated fat, beside olive oil has no cholesterol, while a serving of butter has 33mg of cholesterol. Therefore, fiber optic was using to check the best concentration for olive oil to reduce some fat. In other hand, the new sensor will develop to check the concentrations of olive oil.

1.3 Objectives

Based on the problem statement above, the objectives for the project are:

i. To study and understand fiber optic sensor.
ii. To develop fiber optic sensor for olive oil detection.
iii. To analyse the performance of fiber optic sensor using analysis technique.

1.4 Project Scope

The main objective of this project is to develop fiber optic sensor. The main scope will be discussed in this project is the used of fiber optic**.** The main of this project scope is to make the objectives achieved.

The scopes of work are:

1. Study about fiber optic as sensor to find the concentration of olive oil.
2. Analyze the system establishment for fiber optic as sensor.
3. Data analyze is the power loss of the fiber optic.
4. Analysis will be done by used the olive oil as parameters which has different concentration to obtain the result.
5. The result will analyze and study.

CHAPTER 2

THEORETICAL BACKGROUND

2.0 Introduction

In this chapter, it will include the explanation of fiber optic, fiber optic sensor and concentration of olive oil.

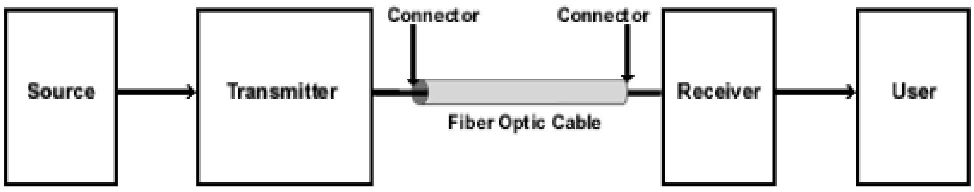

Figure 2.0: Model of “simple” fiber optic data link.

Figure above show three main parts in a model of simple fiber optic which consists source-user pair, transmitter and receiver. The light source is used in fiber optic to emit electromagnetic radiation in order to perform a specific task. While the transmitter is to transmit the source to the receiver.

2.1 Fiber Optic

2.1.1 All-Fiber Optic Acoustic Sensor based on Multimode-Singlemode-Multimode Structure [An Sun, 2011]

Introduction

Acoustic sensor can be widely used in different measurement field of city system engineering such as sound pollution monitoring, or structural noise detection which can be employed for the evaluation of structure health. Comparing with electronic acoustic sensor, many advantages such as immunity to electromagnetic interference, long term monitoring and long transmission distance, make optical fiber acoustic sensor more competitive in extreme application environment than conventional methods. So far many optical fiber related acoustic sensing schemes have been reported such as fiber Bragg grating microphone or DFB fiber laser based hydrophone, and so on.

For most of reported optical fiber acoustic sensors, however, complex sensor structures or expensive demodulation systems are often employed that greatly confines the practical application of optical fiber acoustic sensor. In this paper, a novel optical fiber acoustic sensor based on multimode-single mode-multimode (MSM) fiber structure has been studied. Comparing with other reported scheme, the MSM fiber acoustic sensor has the advantages of simple structure and low cost.

Method

Sensing Principle and Experimental Setup

Multimode-single mode-multimode fiber structure has been used for refractive measurement of liquid in previous report which consists of two multimode fibers (MMF) and a single-mode fiber (SMF). The structure of MSM fiber acoustic sensor is as show in **Figure 2.1** in which a piece of single-mode fiber is spliced between two multimode fibers. When light transmit from multimode fiber to single-mode fiber, part of light will leaks from the core of MMF to the cladding layer of SMF due to the different core diameter between SMF and MMF, which means that part energy of core mode converse to cladding mode.

When the MSM structure is bended, the transmission loss of sensor will be modulated because the coupling efficiency between different fiber core and cladding changes. So the light intensity coupled into the MMF is fluctuating accordingly. In order to detect acoustic wave, the MSM fiber sensor is attached to a thin metal foil which works as an elastic component.

The single-mode fiber used in the experiment is SMF28 with a 9/125m core and cladding diameter. The multimode fiber is step- index AFS105/125Y with a core diameter and cladding diameter of 105m and 125m, respectively. The MSM structure is fabricated by splice a 3cm single mode fiber between two multimode fibers. The elastic metal foil is a circular aluminium membrane with a thickness of 3m and diameter 3cm. Thee single-mode fiber part of MSM sensor is placed at the middle of foil cross the diameter axis. Both side of MSM fiber structure is attached to foil by glue. And the foil is adherent to a fixed hollow circular mount as shown in **Figure 2.2**.

When acoustic wave exert on foil, the sound pressure will induce the deformation of foil, which cause the micro bending of MSM fiber structure. The output intensity of transmission light will fluctuate correspondingly. The vibration then can be detected by measuring the intensity change of transmission light that pass through the MSM fiber sensor. The experimental setup for MSM fiber sensor is illustrated in **Figure 2.3**.

ASE broadband light is used as sensing source with an output power of 4MW and bandwidth 30nm. The output light of ASE source transmits into MSM fiber sensor and a photo detector with a sensitivity of 0.05 V/W@1550nm is used to measure the power of transmitted light at the end of MSM fiber sensor.

Because the frequency range of acoustic wave is up to 20 kHz, a data acquisition card with a sampling frequency of 44.1 kHz and sampling resolution of 16bits is employed to collect the output signal from photo detector according to Nyquist sampling principle. Finally virtual instrument software based on FFT transform is used to analyse the frequency spectrum of signal.

Experiment is carried on to test the performance of MSM fiber sensor. The acoustic wave is generated through a sine signal generator and a loudspeaker. The typical detected acoustic signal at 9 kHz detected by MSM fiber sensor is show in **Figure 2.4**, as frequency domain.

It can be seen clearly that strong background noise exists at low frequency caused by instrument and outside equipment. It is verified by using a sound level meter which shows an environmental noise level of 60dBA during the experiment and which can be eliminated by employing suitable band pass filter.

The acoustic frequency is changed from 1kHz to 11kHz with a step of 1kHz and the frequency response of MSM fiber sensor at different frequency is recorded and analysed. In order to calibrate the frequency characteristic of MSM fiber acoustic sensor, an electronic acoustic sensor with a sensitivity of 1.17mV/Pa@1kHz is employed at mean time in the experiment for contrast. The test results are shown in **Figure 2.5**.

In **Figure 2.5**, it is clear that both MSM and electronic acoustic sensor can sensitively detect the sound signal within the frequency range of 11 kHz. But two sensors exhibit uneven frequency responses. There are three peaks at 2kHz, 5kHz, 7kHz for both sensors but another peak at 10kHz for MSM fiber acoustic sensor.

The unflatness is most likely caused by the uneven frequency response of loudspeaker. In additional, the mechanic characteristics of aluminium foil may also contribute to the frequency response of MSM sensor which shows a more distinct fluctuation than that of electronic sensor. The sensitivity of MSM fiber sensor is very low when sound frequency is beyond 11kHz. But it is possible to achieve a larger frequency detection range by using a proper electronic preamplifier.

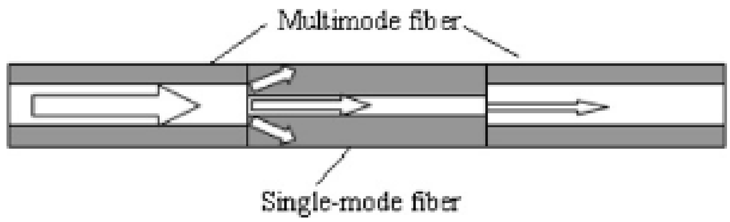

Figure 2.1: Fabrication of MSM fiber.

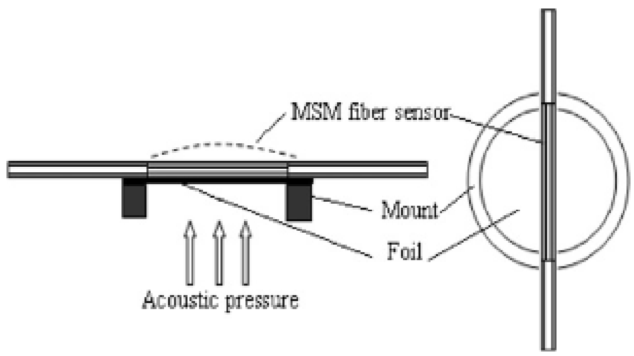

Figure 2.2: Structure of acoustic sensor.

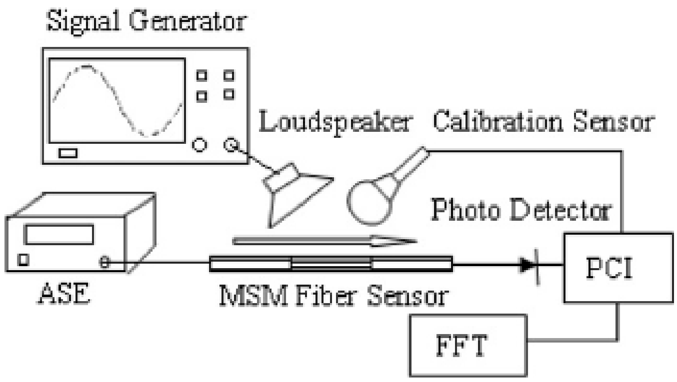

Figure 2.3: Experimental setup for MSM fiber acoustic sensor.

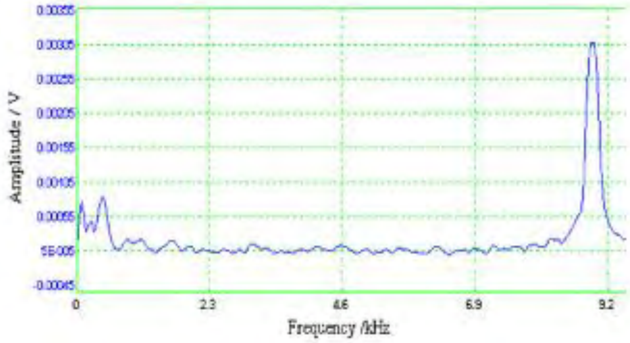

Figure 2.4: Frequency response of MSM fiber sensor to sound wave at 9kHz.

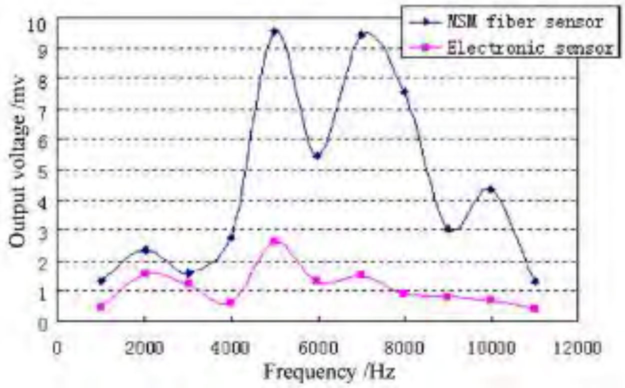

Figure 2.5: Frequency response of MSM fiber acoustic sensor.