Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF LIQUID CONCENTRATION SENSOR USING OPTICAL LOOP FIBER FOR MEDICAL INDUSTRY

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DEVELOPMENT OF LIQUID CONCENTRATION SENSOR USING OPTICAL LOOP FIBER FOR MEDICAL INDUSTRY

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I declare that this project report entitled “Development of Liquid Concentration Sensor Using Optical Loop Fiber for Medical Industry” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

Signature :

Supervisor Name : DR. MD ASHADI BIN MD JOHARI

Date : 28 / 02 / 2022

DEDICATION

To my beloved mother, Puan Lena Maizura and father, Mohd Azman,

To my kind lecturers,

And not to forget, all my dearest friends

For their

Love, Sacrifice, Encouragement, and Prayers

Along with all hard working and respected Supervisor

Dr. Md Ashadi Bin Md Johari

ABSTRACT

This project proposed an application of fiber optic cable as sodium chloride concentration sensor for medical industry purposes. This experiment conducted using an optical loop fiber in three different diameters which then apply for five different sodium chloride concentration range from 10% to 100%. The optic fiber cable will be looped to a diameter that is not excessive to give bending losses. Then, the test will be done for one wavelength only which is 1550nm. Then, the data will be collected are the linearity, sensitivity, stability and repeatability that can be obtained from transmitted spectral graph analysis.

ABSTRAK

Projek ini mencadangkan penggunaan kabel gentian optic sebagai sensor kepekattan Natrium Klorida untuk tujuan industri perubatan. Kajian ini dilakukan dengan mengunakan gelung optik dalam tiga diameter yang berbeza yang kemudiannya dikaji dengan lima kepekatan Natrium Klorida yang berbeza diantara 10% hingga 100%. Kabel gentian optik akan digelung pada diameter yang tidak berlebihan untuk memberikan kehilangan lenturan.. Kemudian, kajian akan dijalankan dengan menggunakan satu panjang gelombang sahaja iaitu 1550nm. Kemudian, data yang akan dikumpulkan adalah linearitas, sensitiviti, kestabilan dan kebolehulangan yang dapat diperolehi daripada analisis grafik spektrum yang dihantar.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

θ_{refr}	-	Angle of Refraction
θ_i	-	Angle of Incidence
θ_c	-	Critical Angle
θ_a	-	Acceptance Angle

LIST OF ABBREVIATIONS

SMF	-	Single Mode Fiber
MMF	-	Multimode Fiber
FOS	-	Fiber Optic Sensor
COD	-	Coefficient of Determination
ASE	-	Amplified Spontaneous Emission
OPM	-	Optical Power Meter
NaCl	-	Sodium Chloride
NA	-	Numerical Aperture
FBG	-	Fiber Bragg Grating
LPG	-	Long Period Grating
WHO	-	World Health Organization

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will briefly discuss on the project background and the problem statement that explained the need of this project to be conducted. This part of the research also elaborates the objective and the scope of this project.

1.1 Project Background

Fiber optics is a technology that is widely acknowledged as an alternative to coaxial cable as a communication medium. Over great distances, light pulses (information) can be transferred via strands made of glass or plastic that are probably about the size of human hair. Since they are non-metallic, they are immune to electromagnetic interference [2]. Also, this technology is said to be safer as they do not carry current that may cause sparks. Their uniqueness makes them capable of transmitting faster over longer distances than other medium does.

Fiber optics was recognized after the discovery of reflection of light in the early 1840s, found by two men [16]. Then, in the 1950s, the world's first endoscopes, dialysis machine was successfully invented to help the doctors to look into the human body without needing to cut it open first. The invention was actually the study of the two German students [16]. Later than, the engineers has discovered a technique to use the same technology on phone calls at the speed of light which is $3x10^8$ ms that is usually 300,000 kilometres per second in a vacuum, but degrading to only about two-thirds the speed in a fiber-optic connection. Fiber optics technology is now being used in wider field to provide fiber-optic internet, phones, TV services, optical gyroscopes, optical hydrophones and etc.

The refractive index and total internal reflection (TIR) are the two most important factors to consider when implementing this light-based technology. Refractive index, abbreviated as n, is defined as the speed of light in a vacuum divided by the speed of light in a material written as v. It genuinely determines how much light is refracted by such a material. As for the total internal reflection (TIR) occurs when light travels and is totally reflected when it approaches a barrier at an angle greater than the critical angle. In the fiber cable, only light that bounces back inside the acceptance angle (maximum angle) will continue to propagate and the sine of this maximum angle is known as the numerical aperture (NA) of the fiber [1].

Over the law few decades, fiber optic has been modified and continuously utilized into sensing technology and known as Fiber Optic Sensor (FOS)[17]. This fiber optic sensor are capable in detecting mechanical strain, liquid concentration, pressure, temperature, displacement and so much more. Fiber optics are resistant to electromagnetic interference and do not conduct electricity, making them ideal for applications involving extremely combustible materials or high voltage electricity without risk. Plus, Fiber Optic Sensors are small, flexible and light weight. Fiber Optic Sensors are also tiny, flexible, and light. The Optical Time-Domain Reflectometer (OTDR) is used by the Optical Fiber Sensor to detect the time delay as the light goes down the cable [18].

Sodium chloride (NaCl) or salt, is one of the most abundant minerals and has been an essential nutrients to living things. Salt has been used to preserve and flavor food for thousands of years. Its use as a preservative helps keep food safe to eat. Aside from preserving and seasoning food, sodium chloride can also be used to make various industrial chemicals. For instance, hospitals use it to provide water and salt to patients to relieve dehydration. Sodium chloride is essential to maintain the electrolyte balance of fluids in a person's body. However, each person must have a balance intake of salt. Too much sodium in bloodstream may affect kidneys' fail to function, increased risk for heart disease, increased water retention, which can lead to swelling in the body and high blood pressure and dehydration. To curb this problem, World Health Organization (WHO) recommended that adults to consume less than 5g of salt daily.

This project is to analyze the performance of the Fiber Optic Sensor in different concentration of Sodium Chloride. Hence, this project is to analyze effect of bending loop fiber which causes much more losses. Besides, this study requires SMF28 optical cable under test, a laser source with wavelength of 1550nm, Optical Spectrum Analyzer (OSA) and five different sodium chloride concentration range from 10% to 100%. The experiment will do for three times repetition for each concentration. and the results that will be obtained from the OSA is the visual spectrum from the output which is the reading at the peak of the spectrum. At the end of the project, one optical concentration sensor with high sensitivity is formed.

1.2 Problem Statement

Medical Industry has been using liquid sensor for such a long time in purpose to monitor human's health such as blood pressure. As in Malaysia, the number of patient with high blood pressure are at stake because of the salt consumption and usage in almost all of their food. Recent liquid sensor always experience electromagnetic interference which leads to uncertain reading. Optical fiber are known with their unique properties and have high performance in sensor therefore it could be used in biomedical field. Thus, this project will be experimenting optical loop fiber in different concentration of Sodium Chloride (NaCl) solution.

1.3 Project Objective

There are several objectives that will be achieved in this project;

a) To study the operation and effect of bending of the optical fiber.

b) To develop Fiber Optic Sensor in different concentration of Sodium Chloride.

c) To analyze the performance of the Fiber Optic Sensor in Sodium Chloride detection.

1.4 Project Overview

There are five chapters in this report. In Chapter 1, the backdrop of the project, the problem statement, the project objectives, and the project scope will be explained. Chapter 2 is a literature review that uses references from books, journals, the Internet, and past projects to acquire a better understanding of the project before it is developed. These materials are the primary source of information for the entire project. After that, Chapter 3 contains descriptions of the project methodology, methodology flowchart, and project process flow. This chapter is very important in order to run the project smoothly. In Chapter 4, the results of the experiments done during PSM 2, will be presented. Finally, the conclusion in Chapter 5 will provide the conclusion of the entire project, the final decision of choosing which optical fiber loop sensor function very well in detecting Sodium Chloride concentration. A few suggestions for future works also included at the last chapter of the project report.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This section included a literature study for the whole project as well as the development of the project. The primary sources would be the additional materials for this project, such as journals, papers, and books from the previous works that are linked to the project's topic. This chapter will elaborates all the related research from the basic knowledge to its applications. This process is important in order to understand the concept of fiber optic and how it works before the next step which to design the Fiber Optic Sensor for sodium chloride liquid concentration.

2.1 Anatomy of Fiber Optics

An optical fiber is known as a flexible, cylindrical dielectric waveguide consisting of low-loss materials such as the silica glass and sometimes plastic. The size of the core with the plastic cladding is slightly thicker than a human hair. The size have been standardized nationally and internationally. It is made up of a central core through which light is steered and an exterior cladding with a slightly lower refractive index as shown in Figure 2.1.

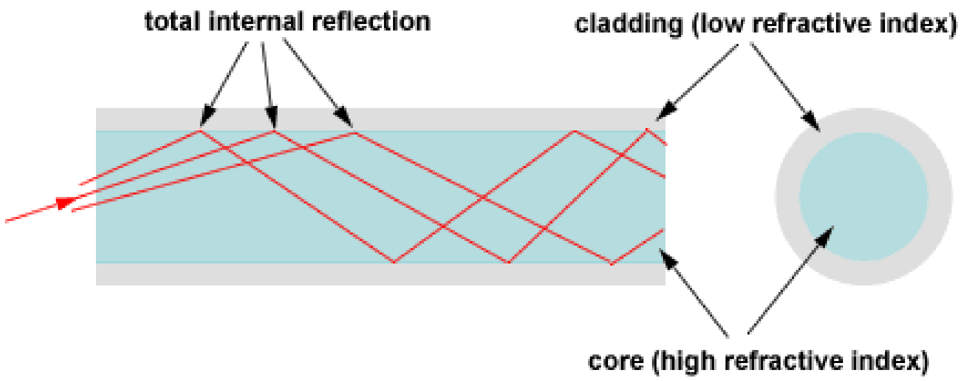

Figure 2.1 – Light reaction to low and high refractive index material.

2.1.1 Fiber Optic Cable Constructions

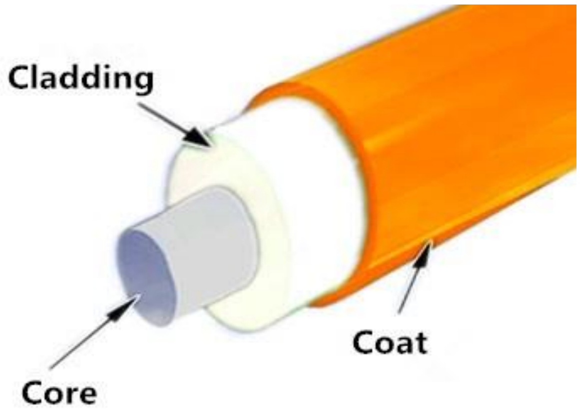

Figure 2.2 – Cross-sectional of optical fiber cable.

The basic structure of an optical fiber cable based in Figure 2.2 consists of core, cladding and coat or buffer. These three layers can be described [2] as below:

a) Core: the transparent cylinder is where the light ray will propagate in. Silica is a most common material used as it is the primary constituent of sand, can easily be found on Earth.

b) Cladding: the first protective layer wrapped around the core. It is also made of silica but with different composition in order to have a lower refractive index than the core so that the light ray to continue travel in the cable by total internal reflection. The cladding helps to strengthen the fiber core from breakage or damage other than reducing the scattering loss due to dielectric discontinuities.

c) Coating: another layer of protection after the cladding layer. It is a non-optical layer and act to protect the fragile optic cable from extreme physical or environmental damage.