UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION PROCESS BY USING DESIGN OF EXPERIMENT (DOE) METHOD TO INCREASE PERFORMANCE OF FIBER OPTIC GLUCOSE SENSOR

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

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 Electronic Engineering Technology (Telecommunication) (Hons.). The member of the supervisory is as follow:

.....

(Aminah binti Ahmad)

ABSTRAK

Pada dasarnya, Reka bentuk eksperimen (DOE) adalah teknik statistik yang digunakan dalam kawalan kualiti untuk merancang, menganalisis dan mentafsirkan set eksperimen bertujuan untuk membuat keputusan yang bijak tanpa menanggung kos yang tinggi dan memakan banyak masa. Masalah-masalah yang berlaku boleh dianalisis dan tindakan penambahbaikan yang boleh dilakukan dengan serta-merta. Terdapat banyak kelebihan menggunakan teknik DOE dan untuk contoh bilangan ujikaji perlu dilakukan boleh menentukan dan dinyatakan dengan jelas mengikut kaedah-kaedah yang terlibat dalam teknik ini seperti Factorial penuh, kaedah Taguchi, Factorial pecahan dan lain-lain. Antara pelbagai jenis DOE yang Reka bentuk eksperimen Factorial adalah salah satu kaedah yang saya reka-bentuk penyelidikan akan memberi tumpuan. Reka-bentuk faktoran dirancang untuk mengkaji fungsi-fungsi bebas-langsung dan sambungan antara faktor-faktor yang mempengaruhi tindak balas. Melalui kaedah Reka-bentuk faktoran, saya mampu untuk menentukan faktor yang optimum yang akan menyumbang kepada penderia gentian optik glukosa dan mengurangkan perubahan melibatkan. Akhirnya, kita boleh mendapatkan keputusan yang lebih tepat dan lebih baik dengan mengulangi menggunakan beberapa jenis factorial. Oleh itu, untuk melaksanakan experimen kaedah Reka bentuk faktoran, kita akan dibantu oleh beberapa parameter terpilih dalam menjana output berdasarkan perubahan kombinasi faktor-faktor yang berlainan. Gentian optik glukosa sensor eksperimen dijalankan dalam Universiti yang majmuk. Selepas mengumpul data yang diperlukan, kita akan mampu untuk plot graf dan memerhati output supaya kita boleh mempunyai kefahaman yang lebih jelas tentang kepentingan setiap faktor yang kami gunakan bagi mendapatkan output yang optimum.

ABSTRACT

Basically, Design of Experiment (DOE) is a statistical technique used in quality control for planning, analysing and interpreting sets of experiments aimed at making wise decisions without incurring a high cost and consuming much time. The problems occurred can be analyzed and an improvement action can be done immediately. There are a lot of advantages of using DOE technique and for example the number of experiments need to be carried out can be define and stated clearly according to the methods that involved in this technique such as Full Factorial, Fractional Factorial, Taguchi Method and etc. Amongst the various types of DOE which is Factorial Design of Experiment is one of the methods in which my research design will be focusing on. Factorial design is planned to study non-direct functions and connections between factors influencing reaction. Through the factorial design method, I am able to determine the optimum factor which will contribute most to the fiber optic glucose sensor and reduce the variation involve. Ultimately, we could obtain a more precise and better result by repeating using several type of factorial. Thus, in order to perform the factorial design of experiment method, we will be assisted by tabulated parameters in generating outputs based on the variation of different combinations of factors. The optical fiber glucose sensor experiment is carried out within the university compound. After collecting the data needed, we are able to plot graphs and observe the output so that we could have a clearer understanding of the significance of each factor that we used in order to get an optimum output.

DEDICATION

Specially dedicated to,

My beloved parents, family members, and friends for your supports, encouragements, understanding, and all the favour. May Allah bless all of you.

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By the name of Allah, the Most Compassionate Most Merciful

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LIST OF SYMBOLS AND ABBREVIATIONS

DOE	=	Design of Experiment
OFAT	=	One Factor at a Time Method
TQM	=	Total Quality Management
TPM	=	Target Performance Measure
NPM	=	Noise Performance Measure
LED	=	Light Emitting Diode
FFD	=	Full Factorial Design
DFSS	=	Design for Six-Sigma
IDDM	=	Insulin Dependent Diabetes Mellitus
NIDDM	=	Non-Insulin Dependent Diabetes Mellitus
MMF	=	Multi-Mode Strands
SMF	=	Single-Mode Strands
PCS	=	Plastic-Clad Silica
ASE	=	Amplified Spontaneous Emission
OSA	=	Optical Spectrum Analyzer
ANOVA	=	Analysis of Variance
LRIS	=	Liquid Refractive Index Sensor
SPR	=	Surface Plasmon Reverberation
dB	=	Decible
nm	=	Nanometer

CHAPTER 1
INTRODUCTION

1.1 Introduction

The design of experiments (DOE) is a standout amongst the most intense quality change systems for decreasing procedure variety, improving procedure viability and procedure ability in the twenty-first century. It is generally perceived in numerous quality designing and administration preparing projects today. Nonetheless, it is fascinating to watch that numerous preparation projects, for example, on the fiber optic glucose sensor and for the most part on the restorative way to deal with the (DOE) however relying upon the mastery of the understudy who gives the strategy on the improvement of fiber optic glucose sensor advancement in an expense of successful and auspicious.

Recently, fiber optic sensors get extensive examination endeavours because of their high affectability, identification velocity and capacities to be utilized as a part of harsh situations. For the glucose sensor estimations are purpose for diabetes patients to focus their insulin measurements admission and constant observing is fundamental to guarantee that glucose level is always within the normal range. As an option, non-invasive glucose sensor procedure are acquainted with add to a torment free measuring strategy. In this venture, a compact glucose sensor gadget is created utilizing close to the chose fiber sensors through the light source. Other than in the identification the concentration of glucose, a fiber optic sensor which can do a precise and legitimate estimation and with great selectivity, low recognition limit, simple utilization, great reproducibility and stability is highly desired against the previous sensor.

1.2 Background of Design of Experiment (DOE)

This study also included the approach of design of Experimental (DOE) where the analysis has carried out to indicate the validity of the process. Therefore, the new approach of DOE will be used. The DOE is a method where the team identifies the parameters that can be controlled and the parameter factors it wishes to investigate. The team then designs, conducts, and analyses experiments to help determine the parameter set points to achieve robust performance (Karl T. Ulrich, Steven D. Eppinger 2011). The Design of Experiments (DOE) has depicted a noteworthy commitment in science and innovation since the time Sir Ronald Aylmer Fisher presented this idea in the 1940s (Belavendram 2011). Therefore, it was broadly utilized by specialists and researchers for item outline and improvement and also handles advancement and change. The idea of test configuration is to yield the most data from the least keeps running of a trial. By applying exploratory outlines in a fiber optic glucose sensor, the improvement lead time and expense could significantly be diminished. Additionally, it would likewise enhance the procedures and items to perform better and accomplish more prominent unwavering quality.

Since 1950s, George Edward Pelham Box (George E.P. Box 2005) and his associates had widely presented experimental design methods in substance procedure and industry improvement. It was utilized to examine and screen the systems or procedures of a specific item. Over the previous decades, there had been a huge increment in the interest and use of test outline procedures in the business environment. By applying such experimental plans, the total quality administration (TQM) had enhanced, at last expanding the organization's or company's income.

The method for directing an experimental design begins with deciding the goals of an examination and distinguishing the components that includes for the study. The experiment methods obliges setting up a point by point trial arrangement ahead of time of leading the analysis, which brings about a streamlined approach in the information accumulation stage. Fittingly picking test outline amplifies the measure of data that can be gotten for a given measure of exploratory exertion. Normally, the design of experiments is divided into three stages, namely as One-Factor-at-a-Time-method, Factorial Experimental design and orthogonal array. The illustration will be as follow figure:

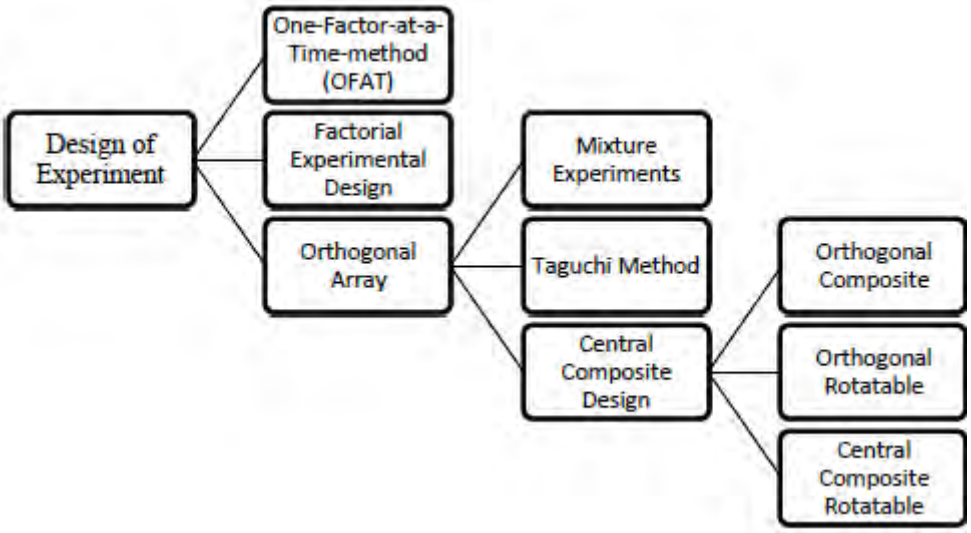

Figure 1.1: The overview of the design of experiment.

1.2.1 One-Factor-at-a-Time-method (OFAT)

Sir Francis Bacon introduced the one-factor-at-a-time method (OFAT) in experimental design. It is the one of the most punctual routines which were usually utilized as a part of trial configuration. As the name recommends, it includes the testing of one element or reason at once rather than at the same time while alternate variables stay constant. The OFAT method could be enhanced advantages compared to factorial experimental design when:

1. The primary goal is to attain improvements in the system.
2. The numbers of runs are limited.
3. The experimental problem is not large compared to factor affects where must be additive and independent of each other.

1.2.2 Factorial Experimental Design

The factorial design technique was spearheaded by Sir Ronald Aylmer Fisher, a British analyst in the 19th century. This statistical methodology fundamental design of experiment was to a great extent grown by him while he was working at Rothamsted Experimental Station. This strategy was further created to incorporate partial plans and reaction surface systems. Fisher additionally distributed "Design of Experiments," In 1935

which a book that stress on the elements of trial exploration plan which is still usually utilized until today.

Factorial design of experiment is a more methodical system used to research the impact of two or more variables towards the yield reaction of a system. Assessing the impacts of different factors on the yield of a procedure with an insignificant number of perceptions is urgent to having the capacity to improve the yield of the procedure. All the conceivable blends of the differing levels of these components are considered for each complete trial of the investigation. Even factorial design guarantees that the minimum number of examination runs are directed to create the greatest measure of data about how include variables influence the yield of a procedure.

According to (Fisher 1926), he claimed that “complex” design (such as factorial design) was more proficient than considering one variable at once. Consequently, the rise of factorial experimental design should be an upgrade variant of the one-component at once strategy. The reasons expressed for favouring the utilization of factorial design over OFAT are:

a) OFAT cannot arrange the interactions between different factors.
b) OFAT needs more runs and consumes much time manner to provide the same precision in effect estimation compared to multi factors design.
c) OFAT has the probability of missing the optimum settings of factors which result in obtaining low experimental results.

1.2.3 Orthogonal Array

A Japanese industrialist, Dr. Genichi Taguchi has popularised orthogonal array experiments. He had used the idea of orthogonal arrays to enhance and focus the best level of control element which expanded the Signal-to-Noise proportions. Taguchi's orthogonal arrays technique arranged all issues into 2 sorts, to be specific Static or Dynamic. In Static issues, the advancement is accomplished for a point reaction by utilizing a Target Performance Measure (TPM) and a Noise Performance Measure (NPM). There are three regular Signal-to-Noise proportions - littler the better, bigger the better and nominal the

best. Then again for Dynamic issues, the enhancement is accomplished for a line reaction by utilizing suitable TPM and NPM in light of the Slope and Linearity of a capacity.

1.3 Problem Statement

Diabetes is a metabolic issue that debilitates human at each age. It happens among grown-ups and elderly, as well as among kids and new born children. As the significance of blood-glucose control for both diabetic and non-diabetic patients keeps on expanding, there is a requirement for more propelled glucose-detecting advancements. However, these projects have huge downsides. Practically speaking, their utilization is oppressive and regularly not exact or particular, particularly in healing centre situations, as they result in conflicting readings with lapses that can surpass 20%. Along these lines, it is suggested utilizing the DOE system as a part of request to help the fiber optic glucose sensor in getting solid information with restricted cost and tests.

A definitive point of this exploration is to apply Factorial Design of Experiment in the optic sensor with the guide data analysis to reduce such variations. It is accept that this project will create the most astounding relative exactness in exploratory configuration. This could be seen when we make the spread sheet utilizing classified parameter information. Also that factorial configuration is additionally more hypothetical contrasted with full factorial design and 2k factorial design. Hence, this might accomplish a more noteworthy exactness of results while performing any experiment.

1.4 Objective

The objective of this project is to design a portable fiber optic glucose monitoring system. The device should be able to detect glucose level in blood or liquid using amplified spontaneous emission (ASE). There are also several objectives that can be determined:

i. To develop and optimize a fiber optic glucose sensor.
ii. To apply the Design of Experiment of fiber optic glucose sensor for a better results.
iii. To identify the sensor parameter that will optimize the output power by using Design of Experiment (DOE).

1.5 Project scopes

In the detection of glucose concentration, the fiber optic sensor which can do a precise and legitimate estimation and with great selectivity, low limit detection, simple usage, great reproducibility and dependability is exceptionally sought. In the detecting of glucose level, a compensation method can be utilized to decrease the adjustment fit as a fiddle of the tip when it inundated in glucose, this strategy can be accomplished from the configuration of sensor test and information handling system. Particularly, design of experiments (DOE) method was used for this study. DOE has been used in an industrial area and currently for medical equipment for a long time because it is useful in getting reliable data with limited cost and samples.

There is much work to be done in the proceeded with progression of this project, and a portion without bounds assignments needed will be quickly highlighted here. As identified with designing parts of the project, the physical dependability and solidness of the sensor will need to be portrayed and advanced, and sensor measurements (e.g., fiber optic diameter) will need to be upgraded to accomplish perfect optical conduct. As specified above, substitute, reduced light sources, for example, LEDs and laser diodes will need to be tested. The design of experiment (DOE) that applied on this project will continuously updated due to the optimization of the sensor and removes the random error during the experiment.

1.6 Project significant

The project significant of the research is 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 figure out as below:

i. Optical fiber sensor that going too used.
ii. Optical sensor that can detect the glucose concentration.

CHAPTER 2
LITERATURE REVIEW

2.1 Experimental Design

A designed experiment is a test or arrangement of tests in which is the reason changes are made to the information variables of a procedure so that it may watch and distinguish relating changes in the yield reaction. The procedure, as demonstrated in (Figure 2.1) can be imagined as some mix of machines, methods, and individuals that changes a data material into an output item. This output item has one or more detectable quality attributes or reactions. Besides, some of the process variables x1, x2, . . . , xp are controllable, whereas others z1, z2, . . . , zq are uncontrollable although they may be controllable for purposes of the test. Sometimes these uncontrollable factors are called noise factors. The objectives of the experimental design including:

1. Identified how the variables are most influential on the response, y.
2. Identified how to set the influential x‟s so that y is near the nominal requirement.
3. Identified how to set the influential x‟s so that variability in y is small.
4. Identified how to set the influential x‟s so that the effects of the uncontrollable variables z are minimized.

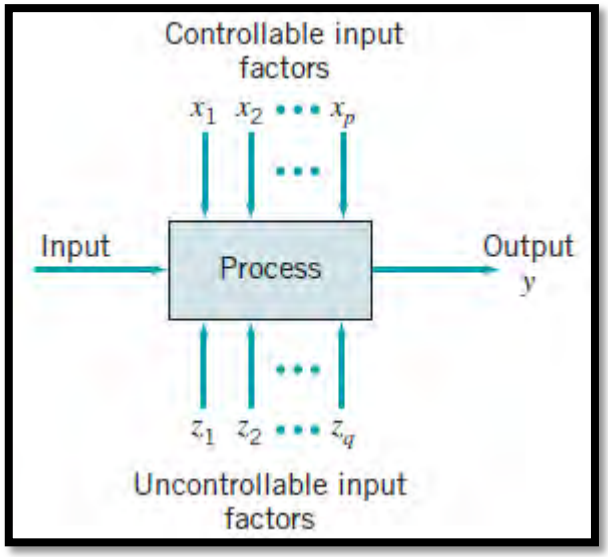

Figure 2.1: General model of a process.

Therefore, the experimental methods may be used either in process development or process troubleshooting to increase the process performance or to provide a process that is robust or insensitive to external sources of variability.

Experimental design and statistical process-control methods, two powerful tools for the improvement and optimization of processes which is necessary used in this project. For example, if a process is in statistical control but still has poor capability, then to improve process capability it will be necessary to reduce variability. In addition if the process is in control, passive observation may not produce much useful information. Besides, experimental design is an active statistical method. This will really perform a progression of tests on the procedure or systems, rolling out improvements in the inputs and watching the corresponding changes in the outputs, and this will also produce information that can lead to process improvement.

Meanwhile, experimental design methods can likewise be exceptionally helpful in setting up statistical control of a procedure. For instance, assume that a control diagram demonstrates that the procedure is wild, and the procedure has numerous controllable data variables. Unless there is information variables are the essential ones, it might be exceptionally hard to bring the procedure under control. Experimental design is a discriminatingly vital designing instrument for enhancing an assembling procedure. It