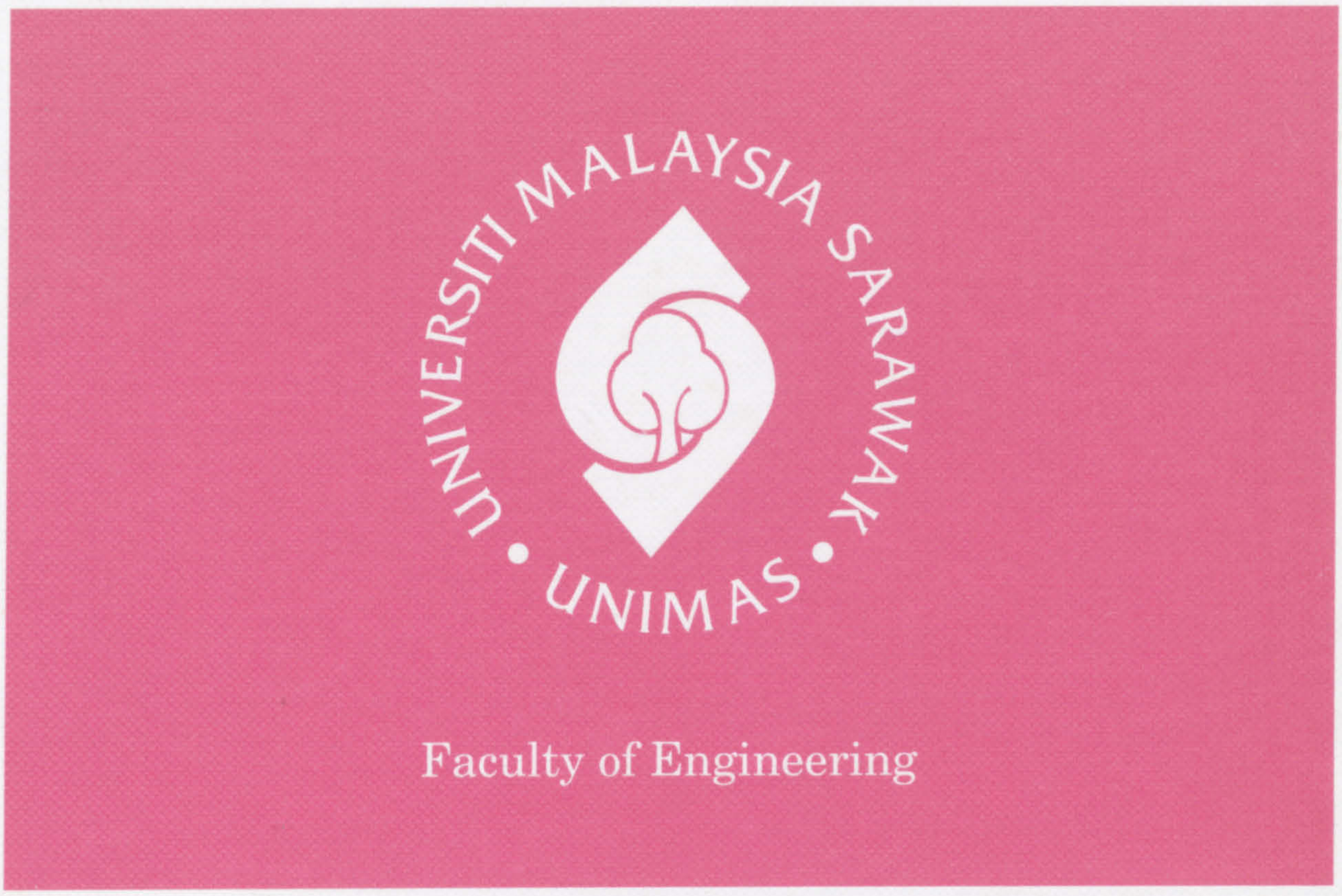

DESIGN, CONSTRUCTION AND EXPERIMENTAL WORK OF A MINI DISSOLVED FUEL ALKALINE FUEL CELL FOR MICRO - ELECTRONIC & MECHANICAL SIGNAL APPLICATION

Gan Yong Kiong

Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing Systems)
2004

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Gan Yong Kiong

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
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SESI PENGAJIAN: 2003/2004

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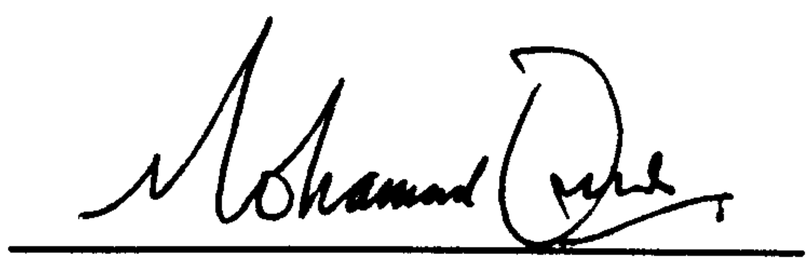

Dr. Mohd Omar bin Abdullah

(Final Year Project Supervisor)

Date: 2nd April 2004

Dedicated to my dearest parents

and my lovely girlfriend

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ABSTRAK

"Fuel Cell" dapat menjanakan kuasa elektrik tanpa sebarang proses pembakaran dalaman. Proses penjanaan "Fuel Cell" tidak mengeluarkan bunyi, getaran serta mencemarkan udara. Dalam projek tahun akhir ini, satu mini "Dissolved Fuel Alkaline Fuel Cell" telah direka bentuk, dibina dan ujian makmal dijalankan. Tujuan pelaksaaan ini ialah untuk mereka bentuk dan membina satu mini "Fuel Cell" yang boleh menghasilkan amaun elektrik yang sederhana kecil. Voltan yang dihasilkan telah terbukti untuk penggunaan bagi mikro-elektronik dan aplikasi isyarat mekanikal contohnya dalam kes ini ialah "Pico Oscilloscope". Oleh itu, ia dapat digunakan sebagai penunjuk kepada isyarat yang tidak diingini seperti gangguan yang terjana semasa disambungkan dengan "Pico Oscilloscope".

ABSTRACT

Fuel cells produce electricity without involving combustion; they generate no noise, vibration nor air pollution. In the current project, a mini dissolved fuel alkaline fuel cell has been designed, constructed and laboratory tested. The purpose of the exercise is to design and construct a mini fuel cell for generating small amount of electricity. The voltage generated had been proven to be useful for micro-electronic and mechanical signal application i.e. the Pico Oscilloscope. As a result, it can be as an indicator of any unwanted signal or disturbance as well as interference when connected to a Pico Oscilloscope.

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CHAPTER 1

INTRODUCTION OF FUEL CELL

1.1 Introduction of Fuel Cell

Fuel Cell is an electrochemical device that used to produce electricity without any internal combustion. As a result, it is considerably a device that generates no noise and vibration. In term of science-fiction fantasy, it is an efficient, nonpolluting power source or environmental friendly device.

1.2 Principle of Fuel Cell

In general, fuel cell could generate electricity continuously by separating the fuel normally hydrogen gas via a catalyst[1]. Besides, it was considered as an energy conversion device which can transform the energy stored in the fuel into electricity and heat. And the fuel is oxidized electrochemically without burning in flame. The basic principle of any type of fuel cell is the protons from the hydrogen gas flow through a membrane and then combines with oxygen to form water by assistance of catalyst. The electrons are flowing from the anode (a negative electrode that repels electrons) to cathode (a positive electrode that attracts electrons) through the external circuit to create electricity. It is usually the pure hydrogen and oxygen as the reactants are supplied to the cell to produce electrical energy. Thus, a fuel cell can produce

electricity continuously as long as the oxygen and hydrogen are supplied to the cell.

In more particular form of explanation, a fuel cell is basically consisted of an anode, an electrolyte membrane in the middle, and a cathode. The fuel hydrogen will flow into the fuel cell anode, and is separated by a platinum coating on anode which then becomes protons, ion hydroxide and electrons. There is an electrolyte membrane in the middle which only allows the protons to pass through the membrane to the cathode of the cell. The electrons will flow through an external circuit in the form of electric current. Thus, the flowing electron will generate a DC (direct current) voltage. In the mean time, the gas oxygen in cathode will combine with protons and electrons to produce pure water and heat.

This individual fuel cell could be then combined into a fuel cell "stack". The number of fuel cells in the stack determines the overall voltage, and the surface area of each cell determines the overall current. Multiplying the voltage by the current yields the total electrical power generated.

1.3 Type of Fuel Cells

Several types of fuel cells had been designed and used up all around the world. The following is the basic classification of a few types of fuel cell:

a) Alkaline Fuel Cells (AFC)

Alkaline Fuel Cells (AFC) was the first type of fuel cell that used for manned space applications and it produces drinking water and electricity. Potassium hydroxide (KOH) solution is particular as the electrolyte in the cell. The operating temperature is within the range of 100˚C -250˚C. The Output of this type of cell is ranges from 300 watts (W) to 5 kilowatts (kW).

b) Proton Exchange Membrane Fuel Cells (PEM)

This is the most common type of fuel cell that used in transportation field. Normally it will operate at the one kW per liter of volumetric powered level at a temperature under 100°C (212 °F). A PEM contains an electrolyte that is a layer of solid polymer (usually a sulfuric acid polymer) that allows protons to be transmitted from one face to the other (Gottesfeld and Zawadinski, 1998). PEM requires hydrogen and oxygen as its inputs. The cell outputs generally

range from 50 to 250 kW.

c) Solid Oxide Fuel Cell (SOFC)

This type of fuel cell can be used at high power consumption machines such as industrial and large scale central electricity generating stations. The output of this type fuel cell is up to 100KW. A hard ceramic compound of metal (such as calcium or zirconium) oxides (chemically, gas oxygen) as their electrolyte is basically used in this particular fuel cell. Reformer is not necessary used to extract hydrogen from fuel due to the high operating temperature that can be as high as 1000°C.

d) Molten Carbonate Fuel Cell (MCFC)

A liquid solution of lithium, sodium and/or potassium carbonates, soaked in a matrix for an electrolyte is basically used in this kind of fuel cell. They promise high fuel-to-electricity efficiencies, about 60% normally or 85% with cogeneration, and operate at about 1,200 °F or 650° C. Units with output up to 2 megawatts (MW) have been constructed, and designs exist for units up to 100 MW. The nickel electrode-catalysts of molten carbonate fuel cells are inexpensive compared to those used in other cells.

e) Phosphoric Acid Fuel Cells (PAFC)

Phosphoric acid is used in this fuel cell as the electrolyte to produce electricity. Existing PAFC has outputs up to 200 kW, and 1 MW units have been tested. Its efficiency ranges from 40 to 80 % and operating temperature is around 150 to 200° C (about 300 to 400° F). Disadvantages of PAF include: it uses expensive platinum as a catalyst, it generates low current and power comparably to other types of fuel cells, and it generally has a large size and weight.

f) Direct Methanol Fuel Cells (DMFC)

This kind of cells is quiet similar to Proton Exchange Membrane Fuel Cells (PEM). Polymer membrane is basically as the electrolyte in both of the fuel cell. In DMFC, the anode catalyst itself draws the hydrogen from the liquid methanol, eliminating the need for a fuel reformer. Methanol is used as electrolyte instead of hydrogen. The Operating temperatures of direct methanol fuel cells are in the same range as PEM fuel cells – 50 to 100°C (122 to 212°F).

1.4 Objectives

The main objective for this final year project is the design, construction and experimental work on a mini alkaline fuel cell for micro-electronic and mechanical application. Besides, there are some others research objectives that need to achieve throughout this project as following:

a) Understanding the fundamental properties and the history of fuel cell.

b) Literature review

c) Theoretical study/analytical method based on the reading

d) Design of a mini fuel cell (Dissolved Fuel Alkaline Fuel Cell).

e) Construction of a mini fuel cell prototype (Dissolved Fuel Alkaline Fuel Cell)

f) Measurement of data, data collection and experimenting of the prototype built.

g) Parametric study and optimization of the influence parameters.

1.5 Methodology of Research

Below are some methods that have been carrying out in order to achieve this final year project:

a) Preliminary study and literature review.

- To understand the working principle of a fuel cell.
- To learn out various types of fuel cell and its elements.
- To understand the calculation of the efficiency and output voltage of a fuel cell.

b) Parametric Experiments

- To find some parameters that influences most of the efficiency in the fuel cell system.

c) Theoretical Calculations

- To calculate the theoretical output voltage and efficiency of the fuel cell

d) Analytical method and theoretical study

- To analyze the experimental result based on the theoretical study.
- Find out the causes and effects of these differences.

e) Work chart

- The work chart for this research is given in Figure 1.1 below.

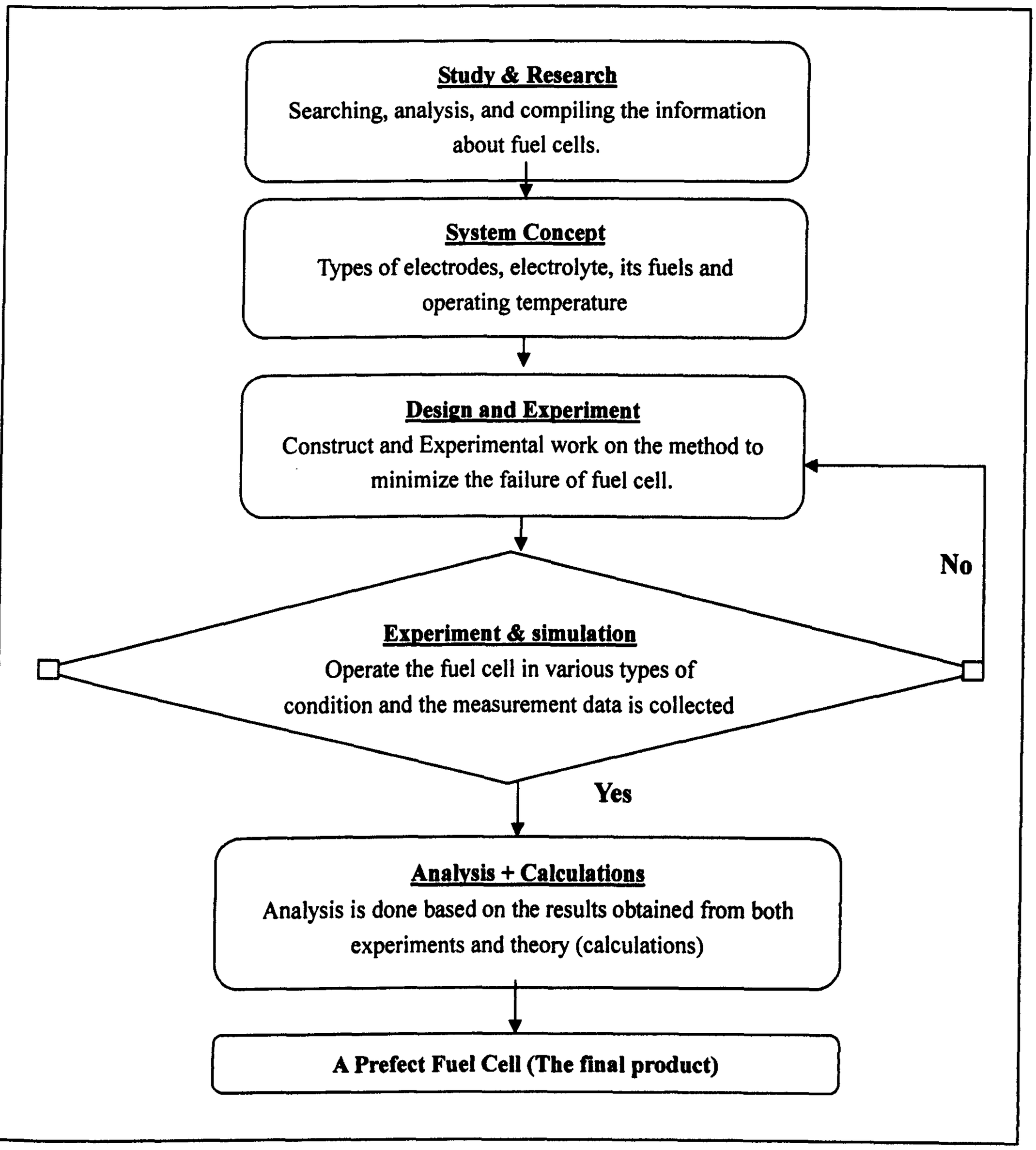

Figure 1.1 Work Chart

1.6 Problems Statement

1) **Cost** - The high capital cost for fuel cells is a largest problem contributing to the development of fuel cell technology in Malaysia. In order for fuel cells to compete realistically with contemporary power generation technology, they must become more competitive from the standpoint of both capital and installed cost (the cost per kilowatt required to purchase and install a power system). For this project to design and construct as well as doing experimental work on a mini fuel cell in UNIMAS, the cost is a major problem in order to get high efficient electrode such as platinum.

2) **Technology & Facilities** – In Malaysia, this newer technology had came across a problem which there are no any suitable facilities such as a machine which can use to construct a bipolar plate for the best contact for producing high efficiency of fuel cell.

3) **Lack Of Information** – It is difficult to find any related information about Fuel Cell Technology in Malaysia. Furthermore, there are no any related consultancies that can assist me when doing this project. The information that had been taken from references such as Web site and reference books are all from oversea countries which are not in complete and still in fundamental research.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

This literature review is taken from several journals, books, articles as well as web site retrieved about fuel cells technology over the past few years. There are six different types of fuel cell technologies available –Alkaline Fuel Cells, Proton exchange Membrane Fuel cells, Solid Oxide Fuel Cells, Molten Carbonate Fuel Cells, Phosphoric Acid Fuel Cells and Direct Methanol Fuel Cells.

Some main points regarding to the physical and chemical properties of the various fuel cells, their advantages and disadvantages, applications are summarized in Table 2.1 to Table 2.6.

The literature had suggested that new potential technologies are now opening to offer alternative solution so as to meet the energy market needs. Perhaps, if the high cost of the materials used to construct fuel cell can be further reduced, fuel cells could become one of the main energy sources over the coming decades. Therefore, research and development should be carried out to find out the most efficiency technologies that can be use to construct a fuel cell.