UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE DEVELOPMENT OF HYDROGEN GENERATOR BY USING WATER ELECTROLYSIS FOR SMALL APPLICATION

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

by

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2016

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SESI PENGAJIAN: **2016/17 Semester 1**

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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 Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

(Mohd Yunos bin Ali)

Lecturer

ABSTRAK

Pembangunan penjanakuasa hidrogen dengan menggunakan elektrolisis air memberi manfaat kepada alam sekitar dan merupakan sumber tenaga boleh diperbaharui. Penjanakuasa hidrogen digunakan untuk menghasilkan hidrogen dan menggunakan hidrogen untuk menghasilkan elektrik. Oleh itu, penghasilan tenaga boleh diperbaharui daripada hidrogen sangat menarik. Penjanakuasa hidrogen adalah satu sistem yang dibangunkan terdiri daripada penyebatian listrik dan sel bahan api. Penyebatian listrik akan digunakan untuk menghasilkan hidrogen manakala sel bahan api digunakan untuk menghasilkan elektrik. Walaupun terdapat banyak penyebatian listrik ada, elektrolisis air akan digunakan kerana proses ini tidak mengeluarkan gas-gas bahaya. Sel bahan api yang digunakan dalam projek ini adalah Sel Bahan Api Membran Pertukaran Proton. Sel bahan api ini adalah yang paling sesuai untuk aplikasi kecil. Objektif projek ini adalah untuk mengenal pasti bagaimana hidrogen menghasilkan elektrik dan penghasilan hidrogen melalui elektrolisis air. Objektif kedua adalah untuk membina satu sistem yang menggunakan hidrogen sebagai sumber tenaga. Skop projek ini hanya memberi tumpuan kepada sistem iaitu penjanakuasa hidrogen. Projek ini juga menggunakan sumber semula jadi iaitu air. Kajian masa depan akan memberi tumpuan kepada penyimpanan hidrogen. Kerja ini meningkatkan pemahaman kita tentang penyimpanan tenaga untuk menghasilkan tenaga sandaran untuk aplikasi masa depan.

ABSTRACT

The development of hydrogen generator by using water electrolysis is beneficial in term of clean environmental and renewable energy source. The hydrogen generator is uses to produce hydrogen and uses hydrogen to produce electricity. Therefore, producing renewable energy from hydrogen is very interesting. Hydrogen generator is a well-developed system consists of electrolyser and fuel cell. Electrolyser will be used to produce hydrogen while fuel cell is used to produce electricity. Though there are many electrolysers available, electrolysis of water will be used as the process does not emit harm gasses. Fuel cell used in this project is Proton Exchange Membrane Fuel Cell(PEMFC). The fuel cell is most suitable for small application. The objective of this project was to identify how hydrogen provides electricity and produce hydrogen by water electrolysis. Second objective is to build a system which use hydrogen as source of energy. Scopes of this project only focus on the system which is hydrogen generator. The project also includes natural source which is water. Future studies will focus on the storage of the hydrogen. This work increases our understanding of energy storage in order to produce backup energy for future application.

DEDICATION

For my beloved family and friends,
whose always believe.

ACKNOWLEDGEMENT

After an intensive period of six months, today is the day: writing this note of thanks is the finishing touch on my project report. It has been a period of intense learning for me, not only in the scientific arena, but also on a personal level. Finishing this project has had a big impact on me. I would like to reflect on the people who have supported and helped me so much throughout this period. I would particularly like to single out my supervisor, Mr. Mohd Yunos bin Ali. I want to thank you for your valuable guidance and for all of the opportunities I was given to conduct my research and further my project. You definitely provided me with the tools that I needed to choose the right direction and successfully complete my project. I would also like to thank my parents for their wise counsel and sympathetic ear. You are always there for me. Finally, there are my friends. We were not only able to support each other by deliberating over our problems and findings, but also happily by talking about things other than just our papers. Thank you very much, everyone!

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CHAPTER 1
INTRODUCTION

1.0 Introduction

The development of hydrogen generator by using electrolysis is beneficial in term of clean environmental and renewable energy source.

1.1 Background of Project

Hydrogen generator can be used as a new technology to store energy especially in applications which involve the safety of the environment and new renewable energy source. Hydrogen generator consist of two parts which are:

1. Electrolyser
2. Fuel Cell

Electrolyzer is used to produce hydrogen for the system[1]. There are many type of electrolyzer available in the market. All electrolyzer are used to produce hydrogen but differ in the type of substance used. For example:

1. Alkaline Water Electrolyzer
2. Proton Exchange Membrane

A fuel cell is a device that converts chemical energy into electrical energy[1].

1.2 Problem Statement

There are several problems that happen which are:

1. Usage of fossil and nuclear fuels can give serious environmental hazard.
2. Decreasing source of energy[2] and renewable energy source demand.

1.3 Objective of Project

There are several objectives mainly focused in this project which are:

1. To identify how hydrogen provides electricity and produce hydrogen by water electrolysis
2. To build a system which use hydrogen as source of energy

1.4 Scope of Project

In summarization, scopes of this project only focus on hydrogen generator which include electrolyzer and fuel cell also may include hydrogen storage. The project also includes natural source which is water.

1.5 Thesis Organization of Project

This report consists of five chapter.

The first chapter is the introduction consist of introduction, background, problem statement, objective project and scope of this project.

The second chapter is literature review consist of background and previous research done by other researchers in the issues related to hydrogen generator and electrolysis of water. This part will cover all fundamental, application and knowledge that need to be understand and justify the best method in order to use in the project.

The third chapter is methodology consist of components of project and ways to do the hardware in this project. The first part of this chapter shows components that will be used. The second part describes ways to setup the project hardware.

The fourth chapter is result and discussion consist of result for hydrogen production and application of hydrogen on electrical appliance. The result and discussion of this project will be presented.

The fifth chapter is conclusion based on the project. The limitation of the project and future works for improving the project will be highlighted.

1.6 Summary

This chapter contains the background of this project where some information is stated about the hydrogen generator. The problem statement is gain based on the related literature review about this project. Therefore, objective is discussed base on problem appeared. The scope of this project is stated where certain part is covered and not covered in this project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

The purpose of literature review is to study about hydrogen, hydrogen production, electrolysis of water and hydrogen generator. The information obtained through the research will be used to conduct the project.

2.1 Hydrogen

Hydrogen is an element which does not freely get from the air although it is the simplest and lightest element on earth. In its pure sort of gas and it combined simply with different components. It is found solely together with different components. Hydrogen must be separated from other element in order to make use of its properties. As associate degree energy carrier, it contains less energy by volume however it has additional energy per weight than the other energy carrier [3]. Although there are several applications of hydrogen, primarily it's used for industrial processes.

2.2 Hydrogen Production

Simple and reliable ways to produce hydrogen and most important is low price method is very for institution and exploitation of hydrogen technology. Nowadays, there are a lot of ways that hydrogen is being produced from many kind of source. The most sources of hydrogen are natural gas, coal, and fossil fuel. However, these generate greenhouse gases which will threaten the environment. These kind of method for producing hydrogen should be scale back.

Hydrogen also can be created from plastic biomass, through a method very like coal chemical process[4]. This method can manufacture synthesis gas that is a mix of hydrogen and carbon monoxide gas.

Another method of hydrogen production is electrolysis of water. Hydrogen production through water electrolysis need electricity in order to create hydrogen. The efficiency of cost will be very low since the production of hydrogen is costly. Renewable energy is recommended since its cost is cheap and does not pollute the environment. Although, every of those alternatives creates a brand new set of queries and challenges[3].

2.3 Electrolysis of Water

The electrolysis of water is very popular and easy method to produce oxygen and hydrogen gas[5]. Water electrolysis need a source of electricity to decompose water. DC power source is enough for these process[6]. In Fig. 2.0 a schematic of fundamental of water electrolysis process is presented.

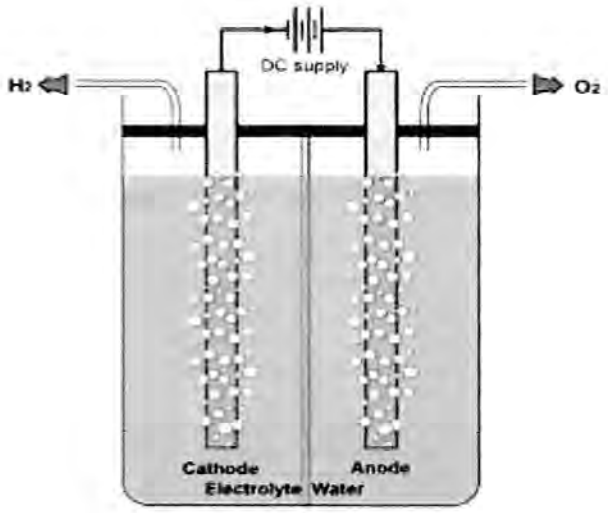

Figure 2.3 The fundamental of water electrolysis process

In water H+ and OH- described by the equilibrium equation:

$$H\,2O\,(l) \leftrightarrow H+\,(aq) + OH-\,(aq)$$

In recent years, lots of alternative strategies are developed in order to produce hydrogen. Example of these technologies are proton exchange membrane electrolysis and steam.

2.4 Hydrogen Generator

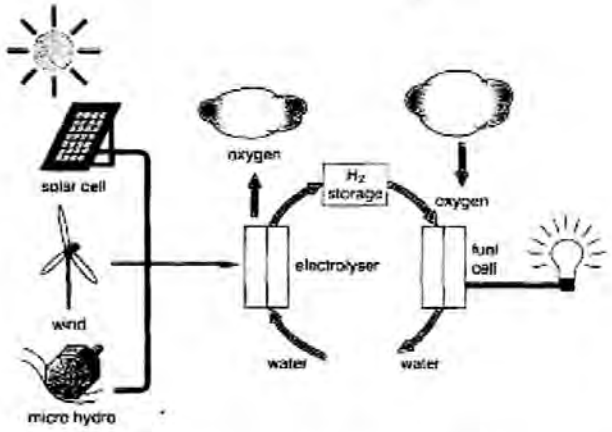

Figure 2.4 Example of hydrogen generator

2.4.1 Electrolyser

The electrolyser is a vital component in order to produce hydrogen[7]. The electrolyzer can be used in two different ways. The electrolyzer can be connected in series connection or parallel connection based on application that will be used.

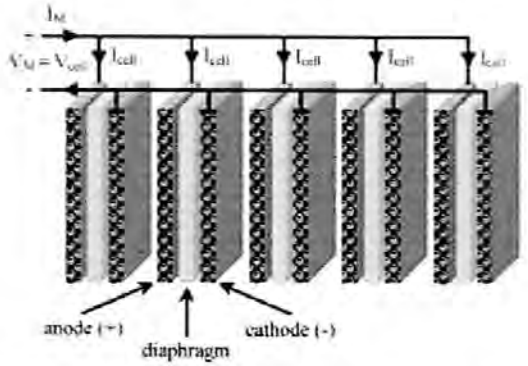

Figure 2.4.1(a) Cells in parallel connection

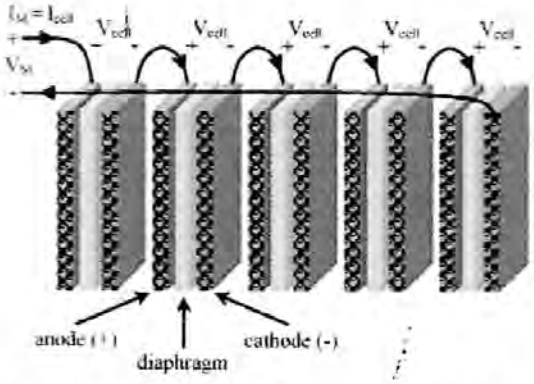

Figure 2.4.1(b) Cells in series connection

Table 2.4.1(a) Comparison between parallel connection and series connection of cells

Aspect	Parallel connection (monopolar)	Series connection (bipolar)
Design	Simple and robust	More complex configuration
Current densities per cell	Low	High
Required voltage	Low(1.9-2.5V)	Low(1.7-1.9V)
Hydrogen production rate	Low	High

There are three type of electrolyser:

1. Alkaline Water Electrolyser

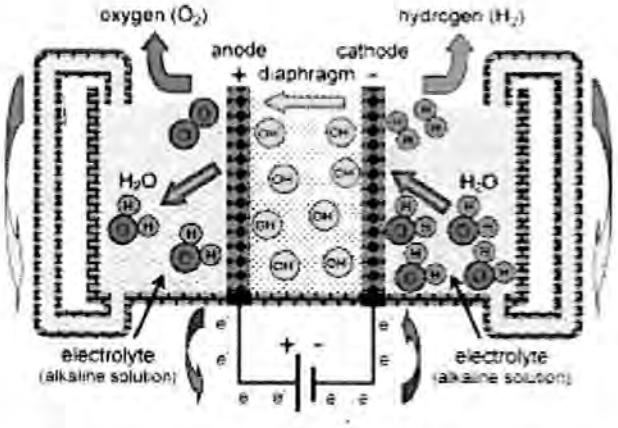

Figure 2.4.1(c) Alkaline Water Electrolyser

2. Proton Exchange Membrane Electrolyser

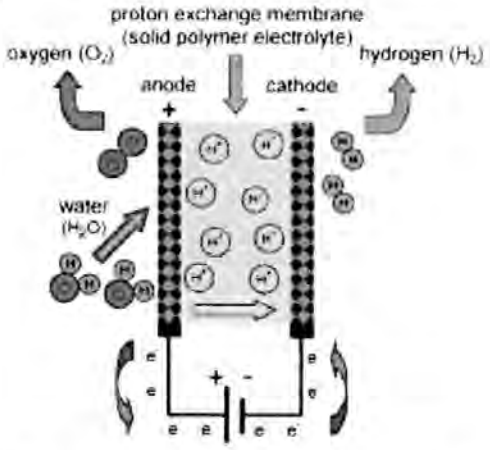

Figure 2.4.1(d) Proton Exchange Membrane Electrolyser

3. Solid Oxide Electrolyser

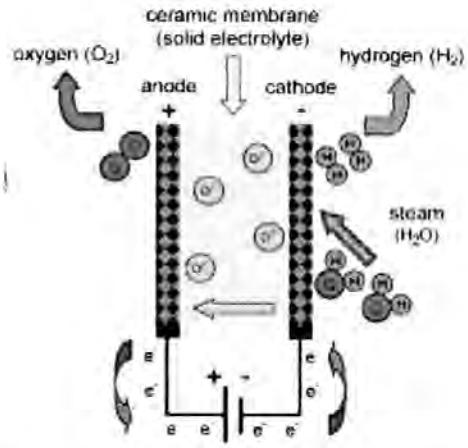

Figure 2.4.1(c) Solid Oxide Electrolyser

Table 2.4.1(b) Comparison between three Electrolysis Technology

Electrolysis Technology	Alkaline Electrolysis	Membrane Electrolysis	High Temperature Electrolysis
Anode Reaction Oxygen Evolution Reaction (OER)	$2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^-$	$H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$	$O^{2-} \rightarrow \frac{1}{2}O_2 + 2e^-$
Cathode Reaction Hydrogen Evolution Reaction (HER)	$H_2O + 2e^- \rightarrow H_2 + 2OH^-$	$2H^+ + 2e^- \rightarrow H_2$	$H_2O + 2e^- \rightarrow H_2 + O^{2-}$
Charge Carrier	OH^-	H^+	O^{2-}
Operating Temperature Range	40 – 90 °C	20-100 °C	700- 1000 °C