A STUDY ON THE PROTON CERAMIC FUEL CELL PERFORMANCE USING FLUID SIMULATION SOFTWARE

MUHAMMAD IRSYAD BIN MISSNAN

Final Year Report Submitted in
Partial Fulfilment of the Requirement for the
Degree of Bachelor of Science (Hons.) (Physics)
in the Faculty of Applied Sciences
Universiti Teknologi MARA

August 2022

ACKNOWLEDGEMENT

First and foremost, I wish to thank Allah S.W.T for giving me the opportunity and wellbeing to embark on my final year project and for completing this long and challenging journey successfully. This project is a compulsory for all student of Faculty Applied Science in the program of Bachelor of Sciences (Hons.) Physics to complete their study.

My greatest gratitude and thanks go to my respectful supervisor Prof Dr. Nafisah Mohd Isa @ Osman for her advice and guidance throughout my journey in completing my final year project. I am also gratefully wish to my advisor, Lidyayatty Abdul Malik for her commitment and endless effort in giving aid to me in completing my project. Also, my sincere thanks to all my lecturers throughout my study in these three years for the knowledge that has been given to me.

The deepest appreciation is also given to Prof. Madya Ts Dr. Hamimah Abd Rahman and Universiti Tun Hussein Onn Malaysia UTHM due to their courtesy and aid in providing the licensed CFD Software; ANSYS 2022 to be used in this simulation project.

Finally, this final year project is dedicated to the loving memory of my very dear parents, families and my fellow friends that supplied me with never-ending support throughout completing my final year project.

ABSTRACT

Combustion engine was known as a main device that can convert chemical energy in a fuel to electrical energy. However, this device produces massive harmful emission that is polluting the environment. Fuel cell is invented as a new device with cleaner emission. Fuel cells convert chemical energy in a hydrogen or hydrocarbon fuel to electrical energy via a healthier process because it only releases water and heat as its emission. One of the fuel cells is named as PCFC (Proton Ceramic Fuel Cell) that utilise hydrogen as their fuel to generate electricity. Different composition of hydrogen will affect the performance of the fuel cell such as their power density. To operate PCFC in 100% hydrogen gas are time-consuming and costly. Thus, in this study, the following two objectives were carried out: i) To obtain a better understanding on the modelling and simulation in the PCFC using computational fluid dynamics (CFD) approach, and ii) To simulate the species mass fraction, temperature distribution and power density of PCFC in 20 - 100% hydrogen gas using CFD model. This study utilised ANSYS 2022 CFD software in modelling and simulating of the PCFC. Two sets of parameters data (experimental and standard data) were used throughout the study. Both data were simulated with two percentage of hydrogen, 20% and 100%. The different fuel percentage did affect the hydrogen mass fraction, and the power density of the fuel cell. However, the temperature distribution did not show any sign of changes with the changes of fuel percentages. Higher fuel percentage made the hydrogen mass fraction to be lower. For power density, the higher fuel percentage lead to higher power density. Maximum power density for experimental data at 100% hydrogen was 338.59 mW/cm^3 compared to 20% was 332.33 mW/cm^3.

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Instead of using combustion engine that will produce pollutants, a device that converts chemical energy to electrical energy with fewer emission such as water and heat is a fuel cell that utilizes hydrogen as its fuel. Fuel cells can be categorized into five main groups that represented by their type of electrolyte and one of them is solid oxide fuel cells (SOFC). The SOFC uses ceramic for its components, electrolyte, and electrodes and operates at high temperature operating (>800℃). Another fuel cell that used ceramic as its electrolyte is a proton ceramic fuel cell (PCFC), however, this fuel cell can operate at a lower temperature than SOFC.

The study of fuel cells performance focused on few elements such as current density, power density, conversion efficiency, and flow distribution of the fuel cell. These characteristics can be obtained using Computational Fluid Dynamic (CFD) that is less costly and more efficient than experimentation. CFD study and simulate the fluid dynamic by using software. Examples of the CFD software that have been used are ANSYS, COMSOL, and CFD-Ace^{+}. The elements that have been studied as mentioned above is influenced by the fuel that be supplied to the fuel cell.

In this study, the PCFC power density is simulated by supplying a different percentage of hydrogen gas. The process of modelling and simulation of the PCFC