

**UNIVERSITI TEKNOLOGI MARA**

**NUMERICAL SIMULATION OF THE  
EFFECT OF OPERATING  
PARAMETERS TOWARDS CHARGE  
TRANSFER COEFFICIENT (CTC) IN  
POLYMER ELECTROLYTE  
MEMBRANE (PEM) ELECTROLYZER**

**FATIN ATHIRAH BINTI MAZLAN**

Thesis submitted in fulfilment  
of the requirement for the degree of  
**Master of Science**  
**(Mechanical Engineering)**

**Faculty of Mechanical Engineering**

**May 2019**

## ABSTRACT

Activation overpotential is a very important parameter in evaluating the performance of PEM electrolyzer, it is one of the major overpotentials that contribute towards overall operating voltage of the electrolyzer. One of the most significant parameters associated with this overvoltage is charge transfer coefficient (CTC). This study aims to contribute to this growing area of research by investigating the effects of operating temperature and CTC on the overall operating voltage. This study also provides an important opportunity to advance the understanding of the effect of different temperature and pressure on the CTC. The result of this study was successfully compared with experimental data. The simulation result shows that, within the temperature range of 10°C to 90°C, the CTC values at the anode electrode ranges between 0.807 and 1.035 while at the cathode electrode, the variation is only within 0.202 to 0.259. It was observed that activation overvoltage decreases when the CTC increase from 0.5 to 2.0 both at anode and cathode electrodes. Interestingly it was observed that the CTC remains the same even at balanced and unbalanced pressure. In spite of that, the performance of PEM electrolyzer had been investigated by efficiency and power supply. It shows that the PEM electrolyzer operates better at a higher temperature. While the power density had been analyzed by using different CTC value which is 0.5, 1.0, 1.5 and 2.0. Therefore, it shows the power density increases significantly with respect to current density. It has been carried out at 60°C, 80°C and 90°C and it shows that, at higher temperature and a specified CTC, the power density increase by a very small fraction. As a consequence, it can be said that, the limiting factor in PEM electrolyzer system was activation overpotential at the anode. Hence, a suitable CTC value can decrease activation overpotential to improve the polarizations.

## ACKNOWLEDGEMENT

Subhanallah, Alhamdulillah and Allahuakbar to our Almighty Allah SWT for giving His endless blessing, knowledge and strength to complete my thesis through ups and down. It is genuine pleasure to express my deep sense of thanks and gratitude to my supervisor Dr. Alhassan Salami Tijani, Senior Lecturer in Faculty of Mechanical Engineering. Thank you for the guidance, patience, and understanding. He also provide me indispensable advice, information and support throughout my time of study here. To my co-supervisor, Dr Hadi Bin Abdol Rahim, thank you very much for giving me a lot of sources for my research.

I would like to give a big thank you for my mother who gives me infinity support until I got here. My brothers, Khairul Jafni, Munir and Muhamad Syukri who are always cheering me up when I got problem to handle this research.

To my beloved husband, Amir Syazwan Bin Mohamad who also serve an inspiration while doing this thesis. Thank you for the support emotionally and physically. With his presence, he make my life so bright and colorful.

Last but not least, I extend my appreciation to my sponsor FRGS 600-RMI/FRGS 5/3 (9/2015) for funding this study.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Research Background

Fossil fuels are produced from creatures buried underneath the Earth's surface since hundred million years back. The existence of fossil fuels such as natural gas, coal and petroleum have provided many benefits for the development of transportation. The burning of fossil fuels cause global warming and this accelerate climate change [1]. Furthermore, the combustion of fossil fuels emit carbon dioxide gases as well as other gases such as methane, nitrous oxides which are eventually trapped in the atmosphere, and later cause a phenomenon known as greenhouse effect.

The uses of fossil fuel to generate electrical energy lead to a vital crisis in order to fulfil the high energy demand of the globe. Meanwhile, the fossil fuel is diminishing and the dispute is intensifying as the environmental issues become worse. Therefore, studies and researches has shown that a paradigm shift from a depleting resource to infinite and reliable resources should be taken to overcome the constraints. Alternative and renewable energy can produce a clean energy to ensure an affordable, reliable and sustainable energy for human beings and it fits the objectives of having sustainable development [2]. The primary sources of renewable energy include solar, hydropower, wind, biomass, and geothermal. These primary sources are captured by natural resources however, according to Fatih Birol [3] in the World Energy Outlook 2014, the carbon emission and greenhouse effect will continue to rise. This is true as stated in Global Carbon Budget 2017 [4], the total carbon emission in 2017 is to be 41 gigatonnes.

Carbon is expected to rise in future, therefore an alternative fuels and technologies should be taken seriously for decarbonized energy system. Another country that is still living without enough power supply is India, while in China, they have taken a rapid change from using coal to a renewable energy in order to combat air pollution that has killed their citizens. Renewable energy sources can be classified into two parts, namely, primary sources and secondary sources. Primary sources of renewable energy can be used or extracted directly from natural resources for instance, wind, water, solar and