Direct Methanol Fuel Cell (DMFC): A Teaching Experiment for Future Engineers

Paul Kalinowski, Afshin Goharzadeh, Arman Molki, and Michael M. Ohadi

Mechanical Engineering Program, The Petroleum Institute, PO Box 2533, Abu Dhabi, UAE
agoharzadeh@pi.ac.ae

1. Introduction

One of the primary objectives of the Petroleum Institute is to prepare future engineers to address both environmental issues and reduction in energy sources. With this in mind, an alternative energy laboratory has been established to provide an essential vehicle to educate engineers on these topics. This laboratory contains state-of-the-art hands on experiments related to sustainable energy and environmental issues. An example of one of these experiments is the direct methanol fuel cell (DMFC). Fuel cells are considered as a promising power source in portable and automotive applications [1-4]. This study outlines a low cost experimental setup for characterization of a single commercial DMFC, which was designed and fabricated in parallel with a senior design project.

2. Key Features

The principle of the direct methanol fuel cell is presented in Fig. 1. It outlines a typical single fuel cell consisted of an anode and a cathode with an electrolyte in-between. A methanol and water mixture enters the fuel cell on the anode side. The electrolyte allows the protons to pass through, but not the electrons. As a result, the protons are directly transported across the electrolyte to the cathode. However, the electrons are directed through an external circuit producing electrical current.

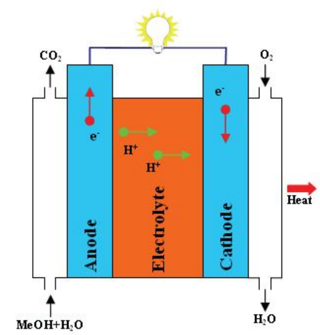

Fig. 1. Operating principle of a DMFC.

Experimental Setup

The experimental setup (Fig. 2) provides the DMFC with aqueous methanol and air. A series of experiments with the single DMFC has been conducted varying various operating parameters such as fuel cell temperature, backpressure, aqueous methanol, air flow rates, and methanol concentration. Experiments were focused on the influence of fuel cell temperature on its performance. Fig. 3 shows the polarization curves for different temperature fuel cell. The relationship between current density and temperature at different cell voltages is shown in Fig. 4. It enables to determine an optimum operating fuel cell temperature.

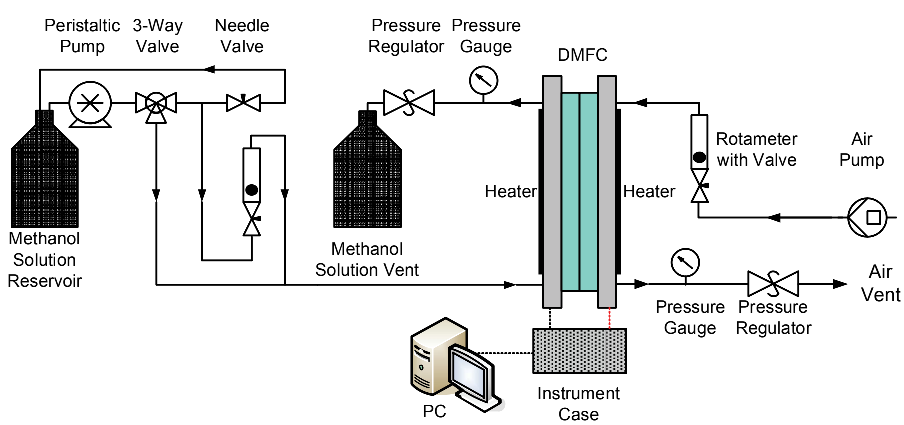

Fig. 2. Schematic of experimental setup.

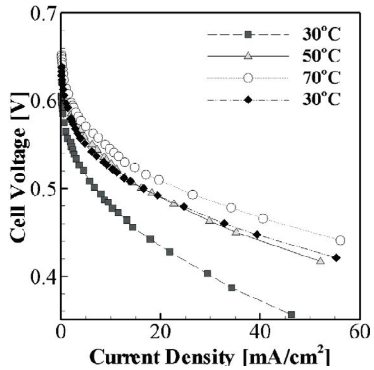

Fig. 3. Polarization curves.

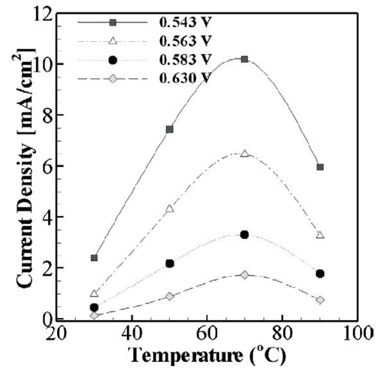

Fig. 4. Optimum temperature.

This experimental set up is a low cost device for teaching the principle of a DMFC to undergraduate students. Table 1 shows the price list for the required components of the proposed teaching DMFC experimental setup. The DMFC experiment costs approximately $5,150 (40% cheaper than the standard systems available on the market).

Table 1: Price list for the components of experimental set up.

Components	Price (USD)
Single DMFC	2,000
DAQ System	310
Peristaltic Pump	1,600
Pressure Pump	240
Hyd. & Elec. Components	1,000
Total:	**5,150**

3. Conclusions

A modern and versatile alternative energy experimental setup based on the direct methanol fuel cell (DMFC) has been presented. The experimental setup satisfies several objectives: enlighten future engineers about major environmental issues related to the oil and gas industry; familiarize students with a modern experimental setup related to sustainable energy; and enhance their knowledge of the operating principle of the DMFC. The DMFC has been tested under different temperatures and the experimental results obtained were presented. The experimental setup is safe, easy to build and facilitates an instructor to teach the basic concept and the performance of the DMFC.

4. References and Bibliography

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Author biographies

Mr. Paul Kalinowski is a Research Assistant in the Mechanical Engineering Program at The Petroleum Institute (PI), Abu Dhabi, UAE. He completed his B.S. degree in Mechanical Engineering from the University of Applied Sciences Mannheim, Germany, in 2006.

Dr. Afshin Goharzadeh is an Assistant Professor of Mechanical Engineering in the Mechanical Engineering Program at the PI. An expert in experimental fluid mechanics, Dr. Goharzadeh obtained his Ph.D. at the University of Le Havre, France, in 2001.

Mr. Arman Molki is a Laboratory Engineer in the Mechanical Engineering Program at the PI. He earned his degree in Computer Science from the University of Maryland, MD, College Park, USA.

Prof. Michael M. Ohadi is a Professor of Mechanical Engineering and the Acting Executive Director of the PI. He is an internationally recognized authority on enhanced heat and mass transfer.

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