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Two-Side-Simultaneously-Observing Test System of Passive DMFC

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Abstract: In order to test passive direct methanol fuel cell and simultaneously observe anode and cathode of a fuel cell, we designed and built a test system. The test system consists of four units: temperature control unit, lighting unit, camera unit and test and data acquisition unit. With a two-floor placement design, we separated tested object and its close auxiliary components from other devices. The design is critical for changing inclination angle between outward normal of anode and gravity direction, which is important to the experiment. The control interface of the test system makes it suitable for a microgravity test system in NMLC (National Microgravity Laboratory Center). Considering the test system will be used for microgravity experiment besides routine normal gravity experiments, many specific issues have been taken into account.

Introduction

Fuel cells are considered to be promising candidates to provide power to electrical vehicles, small and large scale power stations and even portable electrical applications, such as laptop computers and mobile phones. In a manner fuel cell is more efficient, renewable and environmentally friendly than currently exist power sources[1,2,3]. The direct methanol fuel cell (DMFC) has attracted extensive interest because of its simplicity of system, higher energy density, and low toxic emissions [1]. Due to its advantages of removing external pumps and other ancillary devices for fuel and oxidant supply, passive direct methanol fuel cell is considered to be the future hope of portable power source for small devices, alternative to the current widespread application of lithium batteries[4].

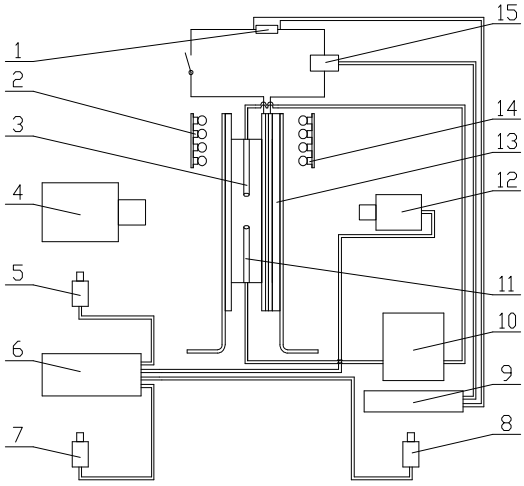

Fig.1 Schematic of the test system
1-Load resistance, 2-Anode lighting, 3-Heating rod, 4-CCD1, 5-CCD3, 6-DVR, 7-CCD4. 8-CCD5, 9-Data acquisition, 10-Temperature controller, 11-Thermocoupl, 12-CCD2, 13-DMFC, 14-Cathod lighting, 15-current transducer

This test system is designed to measure and evaluate a passive DMFC under both normal gravity and microgravity. To conduct the latter experiment, it is designed suitable for the microgravity test system of NMLC (National Microgravity Laboratory Center). By virtue of the integration of tested object and auxiliary devices, it is convenient for us to move the test system and connect it to microgravity test system. To be on the safe side, every part of the system is fixed and protected with elastic material. Fig. 1 shows the schematic of the test system, and fig. 2 is the whole profile of the test system.

Temperature Control Unit

Temperature is one of the key factors that influence fuel cell's performance. We design this test system to measure DMFC working at a temperature range from 40℃ to 70℃. Temperature control unit is composed of a PID temperature controller, a thermocouple and a heating rod. Both of the thermocouple and heating rod are placed in the fuel cell. The power of the heating rod is 60W, and rated voltage is 12V DC. The thermocouple measures the temperature of the fuel cell and sends the signal to the PID controller. Through a specific control strategy, the heating rod is turned on or off. The temperature of the tested fuel cell is regulated through cooperating of part components in the temperature control unit.

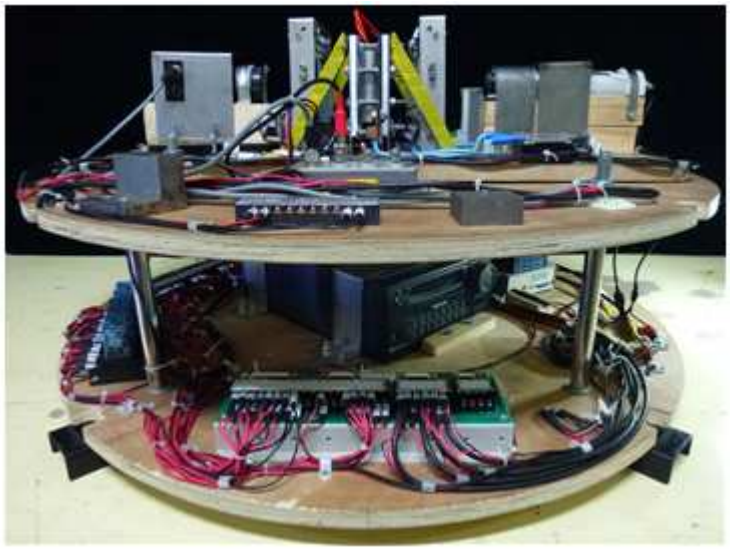

Fig. 2 Two side simultaneously observing Test system of Passive DMFC Test System

Lighting Unit

Considering that the test system is also to be used to measure and evaluate a passive DMFC under microgravity, many issues in test environment must be considered. When conduct microgravity experiment, the entire test system will be sealed in a cabin, where no light comes in. To get high quality clear visual field, appropriate lighting unit is designed. Twenty light emitting diodes (LED) are fixed on a self-designed printed circuit board, and four circuit boards are assembled on a shelf, which is designed and manufactured by ourselves in order to coordinate with the fuel cell to be tested. Fig. 3 shows the lighting effect at the cathode of the fuel cell.

Fig. 3 Cathode lighting system effect

Camera Unit

Camera unit consists of five cameras and a Digital Video Recorder (DVR). Two functions are expected to be realized by designing the camera unit. One of them is to take video of anode two-phase flow and cathode water production. The other one is to monitor the working condition of the measured fuel cell and auxiliary devices. To achieve visual research, we placed two cameras at both sides of the tested fuel cell, one for cathode water production observation (CCD2), and another for two-phase flow observation (CCD1), shown in fig. 4 and fig. 5. To monitor the working state of critical device and temperature of fuel cell, we install three cameras (CCD3, CCD4 and CCD5). CCD 3 monitors the working status of the high speed camera, CCD4 monitors the working status of the DVR, and CCD5 monitors the working status of the data acquisition and the temperature value. For CCD1, we used a high speed camera manufactured by AOS Technologies. It can work with the power of the battery inside of itself as well as the power from the test system. Other four cameras work with the power from the test system of voltage 12VDC.

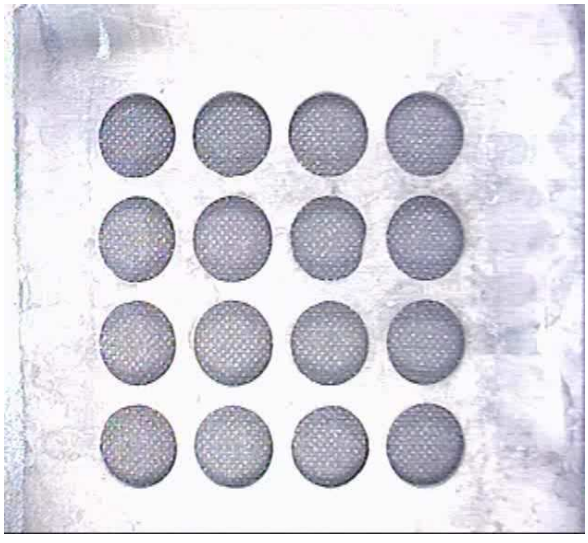

Fig. 4 Cathode picture

Video signals from cameras are send to the DVR, but high speed camera is not included. The high speed camera stores video in itself. With a BNC connector the DVR can be connected to a monitor, displaying all the pictures of the four cameras connected to the DVR.

Fig. 5 Anode picture

Test and Data Acquisition Unit

To evaluate the performance of the fuel cell, we test it with an ARBIN fuel cell test system. With the aid of this equipment, we measured current at different discharge voltage. Then we get polarization curve. Sometimes we need to know the performance of the fuel cell at specific working condition, so we connected the fuel cell with a certain load resistance. Of course a switch is placed in the circuit to realize control of the circuit.

Data acquisition unit comprises of data acquisition box, current transducer, and voltage collector. The data acquisition box is DI710, manufactured by DATAQ Instruments Inc. We used four channels of the data acquisition device, receiving current signal, voltage signal and two gravity signals. Data acquisition device can achieve nine channels. We used four channels to receive and store current signal, voltages and two gravity signals, which are useful only under microgravity condition.

Adjustable Structure

To a great extent, inclination angle between outward normal of anode and gravity direction affects two-phase flow at anode of the passive DMFC. By placing the passive DMFC and its close components at a plate, we can change the inclination angle with gravity without influencing other devices or changing relative place of fuel cell and its close auxiliary components. We designed three working conditions in three different inclination angles between outward normal of anode and gravity direction, that is angel of 45°, 90°and 135°.

Measure Result

The results of experiment are data and pictures, including current and corresponding voltage, anode picture and corresponding cathode picture. With the aid of an ARBIN fuel cell test system we get a polarization curve; and through a load resistance, we get a single plot representing the discharge voltage and current. In theory, the single plot coincides with another plot on the polarization curve. Fig. 6 shows the measurement result of an actual experiment.

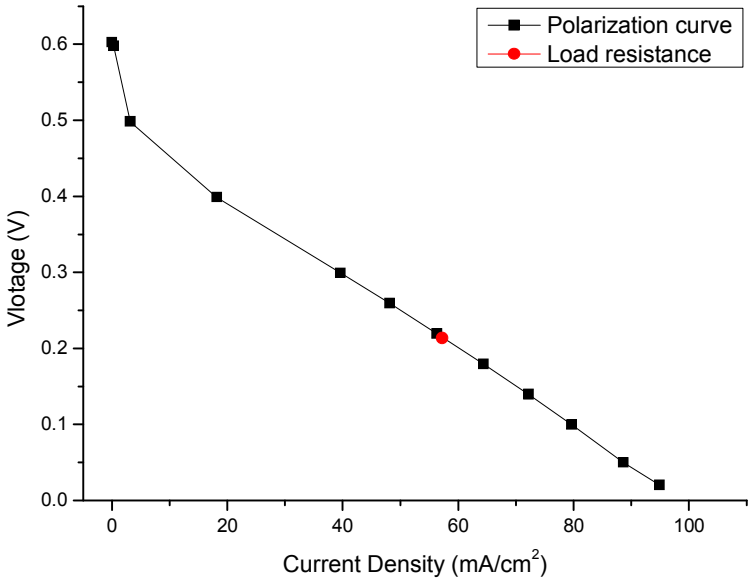

Fig. 6. Polarization curve and single plot of an experiment

Summary

This test system is designed to measure and evaluate a passive DMFC under normal gravity and microgravity. By virtue of its integration of tested object and auxiliary devices, it is convenient for us to conduct experiment, move the test system and connect it to another test system. With temperature control unit we can regulate the fuel cell's temperature to a certain value. With camera unit we can carry out two side simultaneously visual investigation and monitor working conditions of critical devices easily. With the lighting unit, we can get high quality picture of both sides of the fuel cell. By rising the plate carrying the fuel cell and its close auxiliary component, we can change the inclination angle of anode outward normal and gravity direction easily.

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