Data Article

Performance experimental data of a polymer electrolyte fuel cell considering the variation of the relative humidity of reactants gases

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Abstract

The data collected in this article is based on a performance test of a polymer electrolyte fuel cell (PEFC). The behavior of different parameters of a PEFC is analyzed considering different aspects relative to the inlet gases temperatures. The fuel cell was evaluated by means of a current sweep at different percentages of relative humidity between the feed gas and the cell. The relative humidity values were established by means of the temperature setting. The data presented show the experimental response of the cell in real time, which can be used to perform a depth analysis or they can be a starting point for material and performance investigation. In addition, charts presenting the voltage and power density behavior as a function of the volumetric flows of the anode (H2) as well as cathode (O2). The data presented in this article are originally from our research performed in [1].

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Data description

The shared data are obtained from an experimental test where a PEFC was evaluated at different relative humidity conditions by means of a current sweep. This was achieved by configuring the temperatures of the feed gases and the cell in different proportions. Due to the great amount of information, the data are sharing online on the data repository [2], while some relevant diagrams for their analysis are showed in this article. The volumetric flow in the anode and cathode side were considered as independent variables while the voltage and power density were taken as the dependent variable.

1.1. Voltage as power density as a function of the volumetric flow

In Figs. 1 and 2 it can be observed that the behavior of the voltage as a function of the volumetric flow for various relative humidity conditions. The experimental data were obtained by configuring the volumetric flow values using the computational tool for setting the conditions. The stoichiometric ratios employed for the data collection were established at $1.2\times$ for the H$_2$ flow and $2.5\times$ for the O$_2$, both flows were configured based on the applied load. Similarly, in Figs. 3 and 4 the behavior of the power density is shown as a function of the volumetric flow of the anode and the cathode flow fields.

Subsequently in Table 1, a brief part of experimental data collected in the fuel cell performance test is shown, specifically the data shown are for a relative humidity of 16%, having as the Anode/Cell/Cathode temperature settings with values of 40/80/40 respectively. The remaining data for the following relative humidity and temperature settings are displayed in the data repository [2]. The data shown were recorded according to the time step, where the parameters as current, current density, power density, cell voltage, anode temperature (hydrogen inlet), cell temperature, cathode temperature, and so on.
temperature (oxygen inlet), volumetric flow in the anode and cathode, were collected directly by using a fuel cell data acquisition.

2. Experimental design, materials, and methods

2.1. Data acquisition

The data acquisition system consists of a Fuel Cell® software, a GPIB Instruments control device cable and a fuel cell test System from Scriber®. The use of the mentioned tools allows us to control the input variables of the experiment from a peripheral device. Variables such as the inlet temperatures of the H₂/O₂ feed gases were controlled, the respective volumetric flows and the current load applied to the cell were tested as every step in the process of the data collection. Also, by means of the computational tool it is possible to control the opening of the valves of the system, and to configure the different types of experiments that can be carried out with the equipment. For more information on the fuel test System readers are referred to Ref. [3].

2.2. Experimental design

Initially, an inlet pressure of the H₂/O₂ feed gases was set at 55 psig, N₂ was used as a purge gas to keep the flow distribution system clean and avoid the reactions with the other reagents. The water used was ASTM type I (with 18 MΩ cm⁻¹ minimum resistivity), because the membrane electrode assembly should be prevented from contamination. The evaluation of the performance of the cell in several conditions of relative humidity was carried out to perform an analysis based on the maximum efficiency temperature of the cell, i.e., 80 °C [4]. The mentioned temperature is kept constant, then a configuration was made for the gases entering to the systems. Temperature of the gases are established in the range of 40 °C–80 °C, in steps of 10 °C. This temperature step corresponds to the double of the considered in a previous research that involve a PEFC with similar characteristics [5].

Fig. 1. Voltage of a single cell as function of the gas flow at the anode side measured at several percentages of relative humidity.
Fig. 2. Voltage of a single cell as function of the gas flow at the cathode side measured at several percentages of relative humidity.

Fig. 3. Power density of a single cell as function of the gas flow at the anode side measured at several percentages of relative humidity.
Fig. 4. Power density of a single cell as function of the gas flow at the cathode side measured at several percentages of relative humidity.

Table 1
Experimental data collected in the fuel cell performance test at 16% of relative humidity, i.e., Anode/Cell/Cathode temperatures are 40/80/40 respectively.

| Time (s) | Current (A) | Current Density (mA.cm\(^{-2}\)) | Power Density (mW.cm\(^{-2}\)) | Voltage (V) | Temp. Anode (°C) | Temp. Cell (°C) | Temp. Cathode (°C) | Flow Anode (L.min\(^{-1}\)) | Flow Cathode (L.min\(^{-1}\)) |
|----------|-------------|-----------------------------------|---------------------------------|-------------|------------------|-----------------|-------------------|--------------------------|--------------------------|
| 60       | 0           | 0.000                             | 0.0                             | 0.797       | 40               | 80              | 40                | 0.0470                   | 0.0716                   |
| 120      | 0.253       | 10.115                            | 7.5483                          | 0.746       | 40               | 80              | 40                | 0.0477                   | 0.0870                   |
| 180      | 0.501       | 20.031                            | 14.1320                         | 0.706       | 40               | 80              | 40                | 0.0473                   | 0.1017                   |
| 240      | 0.751       | 30.035                            | 20.1330                         | 0.670       | 40               | 80              | 40                | 0.0472                   | 0.1145                   |
| 300      | 1.000       | 39.988                            | 25.5790                         | 0.640       | 40               | 80              | 40                | 0.0476                   | 0.1288                   |
| 360      | 1.249       | 49.956                            | 30.6690                         | 0.614       | 40               | 80              | 40                | 0.0468                   | 0.1422                   |
| 420      | 1.496       | 59.833                            | 35.3510                         | 0.591       | 40               | 80              | 40                | 0.0469                   | 0.1564                   |
| 480      | 1.751       | 70.046                            | 39.8770                         | 0.569       | 40               | 80              | 40                | 0.0471                   | 0.1706                   |
| 540      | 2.002       | 80.071                            | 44.0980                         | 0.531       | 40               | 80              | 40                | 0.0477                   | 0.1828                   |
| 600      | 2.250       | 89.985                            | 47.7790                         | 0.531       | 40               | 80              | 40                | 0.0468                   | 0.1973                   |
| 660      | 2.503       | 100.130                           | 51.5400                         | 0.515       | 40               | 80              | 40                | 0.0471                   | 0.2129                   |
| 720      | 2.749       | 109.960                           | 54.9260                         | 0.499       | 40               | 80              | 40                | 0.0469                   | 0.2252                   |
| 780      | 2.997       | 119.890                           | 57.9080                         | 0.483       | 40               | 80              | 40                | 0.0473                   | 0.2381                   |
| 840      | 3.249       | 129.950                           | 60.8590                         | 0.468       | 40               | 80              | 40                | 0.0473                   | 0.2510                   |
| 900      | 3.498       | 139.930                           | 63.2700                         | 0.452       | 40               | 80              | 40                | 0.0467                   | 0.2655                   |
| 960      | 3.745       | 149.800                           | 65.1920                         | 0.435       | 40               | 80              | 40                | 0.0469                   | 0.2800                   |
| 1020     | 3.999       | 159.950                           | 66.7140                         | 0.417       | 40               | 80              | 40                | 0.0470                   | 0.2924                   |
| 1080     | 4.251       | 170.040                           | 67.8990                         | 0.399       | 40               | 80              | 40                | 0.0500                   | 0.3046                   |
| 1140     | 4.497       | 179.860                           | 68.4970                         | 0.381       | 40               | 80              | 40                | 0.0528                   | 0.3203                   |
| 1200     | 4.750       | 189.980                           | 69.1510                         | 0.364       | 40               | 80              | 40                | 0.0557                   | 0.3344                   |
| 1260     | 5.000       | 200.010                           | 68.6420                         | 0.343       | 40               | 80              | 40                | 0.0581                   | 0.3497                   |
| 1320     | 5.246       | 209.860                           | 67.7860                         | 0.323       | 40               | 80              | 40                | 0.0611                   | 0.3610                   |
| 1380     | 5.493       | 219.720                           | 63.9450                         | 0.291       | 40               | 80              | 40                | 0.0636                   | 0.3752                   |
| 1440     | 5.749       | 229.950                           | 60.4080                         | 0.263       | 40               | 80              | 40                | 0.0671                   | 0.3904                   |
| 1500     | 5.998       | 239.920                           | 53.6770                         | 0.224       | 40               | 80              | 40                | 0.0698                   | 0.4060                   |
| 1560     | 6.251       | 250.030                           | 39.4610                         | 0.158       | 40               | 80              | 40                | 0.0710                   | 0.4172                   |
humidity calculation was obtained as the ratio between the saturation pressure of the cell at 80 °C and the saturation pressure of the feed gases at their corresponding inlet temperature. This analysis can be carried out since the system has humidifier tanks which saturate the feed gases to their dew point, according to the set temperature. This experiment was designed considering some specifications described in Ref. [6]. The temperature of the gases play an important role during the energy conversion process specially when phase change occurs [7].

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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