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Short communication

The neural networks based modeling of a polybenzimidazole-based polymer electrolyte membrane fuel cell: Effect of temperature

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ABSTRACT

Neural network models represent an important tool of Artificial Intelligence for fuel cell researchers in order to help them to elucidate the processes within the cells, by allowing optimization of materials, cells, stacks, and systems and support control systems. In this work three types of neural networks, that have as common characteristic the supervised learning control (Multilayer Perceptron, Generalized Feedforward Network and Jordan and Elman Network), have been designed to model the performance of a polybenzimidazole-polymer electrolyte membrane fuel cells operating upon a temperature range of 100–175 °C. The influence of temperature of two periods was studied: the temperature in the conditioning period and temperature when the fuel cell was operating. Three inputs variables: the conditioning temperature, the operating temperature and current density were taken into account in order to evaluate their influence upon the potential, the cathode resistance and the ohmic resistance. The Multilayer Perceptron model provides good predictions for different values of operating temperatures and potential and, hence, it is the best choice among the study models, recommended to investigate the influence of process variables of PEMFCs.

1. Introduction

Polymer electrolyte membrane fuel cells (PEMFCs) are receiving a growing interest for many potential power sources applications, both stationary and portable. The typical electrolyte membranes used in PEMFCs are Nafion or other perfluorcarbon sulphonic acid membranes. These have some limitations due to the presence of water required to be proton conductor and then, the temperature is limited to 90 °C at atmospheric pressure. Moreover, working above this temperature, the catalysts of PEMFCs are more tolerant to the presence of contaminants, overall higher operating temperature eliminates CO poisoning by eliminating CO occlusion of the platinum sites. In order to overcome this limitation, it has been proposed to raise the operating temperature [1–3]. This increase implies that all the materials used for this purpose must withstand those conditions (thermal stability), aside from having the adequate properties for their use in PEMFCs (e.g. proton conductivity for the polymeric membrane, catalytic activity for the electrocatalyst, chemical stability, mechanical stability, reliability, durability).

Polybenzimidazole (PBI), the polymer used in this work, can be included within the group of polymeric electrolytes proposed for High Temperature PEMFCs. When PBI is impregnated with phosphoric acid, it presents some interesting properties such as increasing of conductivity up to 200 °C which is acceptable and rising of thermal and chemical stability above the level. Thus, acid doped PBI can be used as polymeric electrolyte in High Temperature PEMFC [4–8]. A possible limitation of this system is the H_3PO_4 stability within the PBI system, known as phosphoric acid is self-dehydrated and generates oligomers of the original acid, e.g., pyrophosphoric acid, at 140 °C [9] which leads to low conductivity [5]. Consequently, this undesirable process would produce a gradual decay of the cell performance. Thus, this process may degrade the cell performance along the time.

Detailed modeling of PEMFC has been of considerable interest in predicting the fuel cell performance and also for use in various systems engineering activities. Hence, there has been recent interest in building simply, cost reductive and time saving. Among the many possibilities, artificial neural networks (ANN) represent a good alternative choice [10].

The use of neural networks has become increasingly recommended for applications where the mechanistic description of the interdependence between variables is either unknown or very complex. Their parallel organization and their capability to learn from

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