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Novel hybrid fuzzy-PID control scheme for air supply in PEM fuel-cell-based systems

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ABSTRACT

This paper proposes a novel hybrid fuzzy-PID controller for air supply on Proton Exchange Membrane fuel cell (PEMFC) systems. The control objective is to adjust the oxygen excess ratio at a given setpoint in order to prevent oxygen starvation and damage of the fuel-cell stack. The proposed control scheme consists of three parts: a fuzzy logic controller (FLC), a fuzzy-based self-tuned PID (FSTPID) controller and a fuzzy selector. Depending on the value of the error between the current value of oxygen excess ratio and its setpoint value, the fuzzy selector decides which controller should play the greatest effect on the control system. The performance of the proposed control strategy is analysed through simulations for different load variations and for parameter uncertainties. The results show that the novel hybrid fuzzy-PID controller performs significantly better than the classical PID controller and the FLC in terms of several key performance indices such as the Integral Squared Error (ISE), the Integral Absolute Error (IAE) and the Integral Time-weighted Absolute Error (ITAE), as well as the overshoot, settling and rise time for the closed-loop control system.

Introduction

The serious environmental pollution and energy crisis around the world are driving innovation on new efficient and clean energy sources such as solar, wind, geothermal and hydrogen. Fuel cells are a kind of clean energy, which produce electricity, water and heat from hydrogen and oxygen [1–3].

In particular, Proton Exchange Membrane fuel cells (PEMFC), also called solid polymer fuel cells (SPFCs), are considered to be more developed than other types of fuel cells [4–6]. They are used in a wide range of applications, with advantages such as high efficiency, low weight, low pollution and low operation temperature, features that allow fast starting times in the PEMFC systems [7,8]. However, high expenses and short lifetime have hindered their massive utilization in real systems so far. As a result, advanced control systems are required to improve the lifetime and avoid the detrimental degradation of the PEMFC system.

Many control strategies have been proposed for PEMFC systems in the literature. It can be cited, among others, linear

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