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Multi-agent reinforcement learning based coordinated control of PEMFC gas supply system

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Abstract

This paper proposes a multi-agent reinforcement learning algorithm for the coordinated gas supply control of PEMFC to improve efficiency and extend service life by regulating differential pressure of anode and cathode, oxygen excess ratio and anode inlet humidity. Firstly, the coordinated gas supply model of PMEFC is established to provide the environment used to remodel the Markov decision process and interact with agents, and then the control frame considering air supply, hydrogen supply and anode circulation gas supply is designed to realize coordinated control. The control algorithm is finally evaluated in the matlab&simulink environment, and compared with the traditional PID. The results show that the proposed algorithm is superior to traditional PID in steady-state error and dynamic response.

Model and Controller

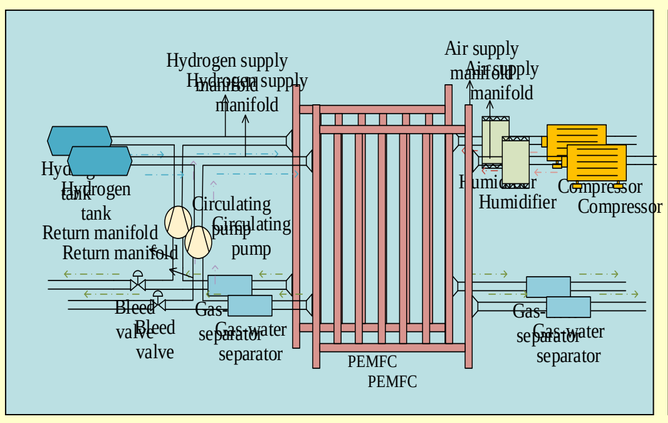

Fig 1 PEMFC structure diagram

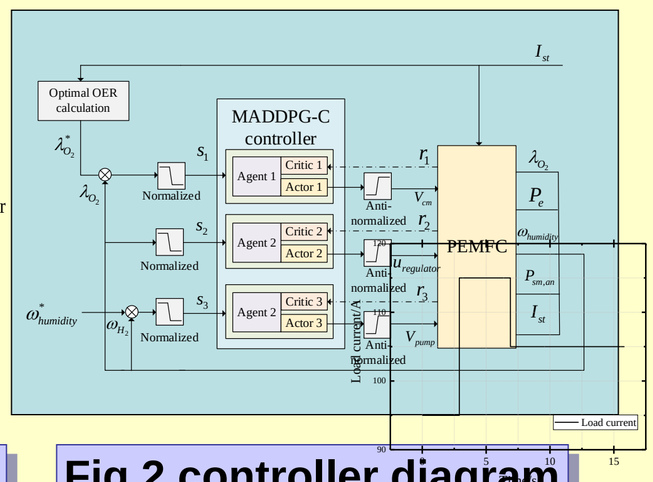

Fig 2 controller diagram

As Fig 1, the simulation model consisting of air supply subsystem, hydrogen supply subsystem and hydrogen recycle subsystem is developed to re-model the control problem into a MDP. Then the MADDPG algorithm is adopted to realize the cooperative control as Fig 2 by controlling the compressor voltage, the circulating pump voltage and the set pressure of hydrogen pressure regulator. In the training process, the critic of agent obtains the global action, state information and the single step reward to train the judge ability for good actions, and improves the actor policy by maximizing the Q value. In the test process, the actor of agent only get the state information of itself to decide an optimal action with a large single step reward.

Simulation Results

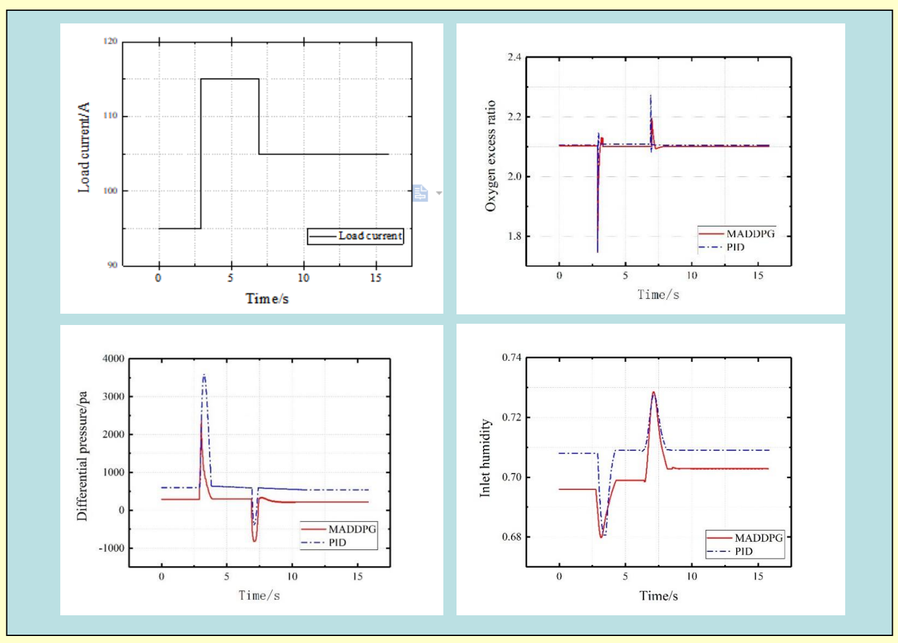

Fig 3 simulation and results

In Fig 3, the proposed method is compared with traditional PID through a case study the adding step load current. the MADDPG controller has better dynamic and steady performance than the PID controller in tracking excess oxygen ratio, anode inlet humidity and hydrogen recycle ratio. Thus the PEMFC with MADDPG controller for its gas supply system has better efficiency and longer service life.

Summary

In order to improve the efficiency and extend service life of PEMFC, A multi-agent reinforcement cooperative control method for the PEMFC gas supply system was proposed in this paper. The three agents regulated oxygen excess ratio, anode inlet humidity and the differential pressure between anode and cathode by controlling the voltage of the air compressor, the voltage of the circulating pump and the set pressure of the hydrogen pressure regulator respectively. MADDPG algorithm is adopted to develop the agents and interact with the established PEMFC model through centralized training and decentralized execution. The load current step simulation was carried out with MADDPG controller and PID controller to demonstrate the superiority of proposed approach.