Preface

The internal combustion engine power reflects the essence of human wisdom for a whole century, but its fatal weakness is environmental pollution. Nowadays, the world's oil resources have been exhausted day by day, and it is difficult for internal combustion engines to fundamentally get rid of this passive disadvantage. The development of electric vehicles has attracted much attention in the face of increasingly severe energy and environmental protection. Hydrogen is an excellent energy carrier with many unique properties, which is the lightest, most efficient, and cleanest fuel. One of its unique properties is that through electrochemical processes, it can be converted to electricity in fuel cells with higher efficiency than conversion of fossil fuels to mechanical energy in internal combustion engines or to electrical energy in thermal power plants. This unique property of hydrogen has made hydrogen fuel cells the automotive power plant of choice for car companies. Fuel cell electric vehicles are high-efficiency, clean, and zero-pollution that were first produced in the 1970s and have developed rapidly in the last 10 years. The car with the proton exchange membrane fuel cell as the power source is called the fuel cell electric vehicle, and the power system structure and energy management strategy of the whole vehicle is the hot spot and key technology of the whole fuel cell electric vehicle research.

There are two types of fuel cell electric vehicles in a broad sense: pure Fuel Cell Electric Vehicles (FCEV) and Fuel Cell Hybrid Vehicles (FCHV). The former uses only the fuel cell system as the power source, and the fuel cell supplies power to the vehicle drive system; the latter is powered by a battery pack or supercapacitor in parallel with the fuel cell system. At present, there are many technical obstacles that makepure fuel cell vehicles difficult to commercialize. The FCHV overcomes some of the obstacles in pure electric vehicles and offers potential for improving vehicle performance. Specifically, the FCHV has two advantages: ①it offers great potential for fuel savings by load-leveling the fuel cell stack; ②it uses a smaller battery pack compared with the pure electric vehicle.

The detailed contents of this book are as follow:

Chapter 1: The research background was described.

Chapter 2: In this chapter, related researches about modeling of PEMFC were introduced and then the working principle of PEMFC was described. A series of typical PEMFC models were introduced, such as the mechanism model, empirical model, one-dimensional model, two-dimensional model, and three-dimensional model. The Dynamic model of PEMFC was established based on MATLAB/Simulink which included six parts: ① membrane hydration; ②cathode mass flow; ③anode mass flow; ④stack voltage; ⑤cathode gases diffusion layer (GDL); ⑥ anode gases diffusion layer. After analyzing the influence of several important design parameters and operation parameters, the cooling effect of an air-cooling battery cooling system was improved.

Chapter 3: The whole FCHV model based on ADVISOR was introduced and serious of subsystem models were built in MATLAB/Simulink: ①Fuel Cell Pack Model; ② NiMH Battery Pack Model; ③ Motor Model; ④ Driver Model; ⑤FCHV Power Train Model. Some assumptions were made to simplify the fuel cell stack model and NiMH Battery Pack Model.

Chapter 4: The theme of this chapter was the optimization and control of the PEMFC system. In this chapter, the PEMFC system model which was established in Chapter 2 was verified and used to optimize the control of PEMFC system. The analysis of the oxygen excess ratio was conducted and two air supply controllers (Time Delay Controller and Feedforward fuzzy-PID Controller) were proposed. To achieve the maximum output power and the minimum usag of hydrogen in a certain power condition, optimization was carried out using Response Surface Methodology (RSM) based on the proposed PEMFC stack model.

Chapter 5: Based on the MATLAB/Simulink, an overall simulation model for the fuel cell hybrid vehicle power train in parallel configuration has been constructed with power control strategy using logic threshold approach achieved by the Hybrid Control Unit (HCU) to assure that the power delivered by the electric motor meets the power demand under different operation environments. By using the D-optimality method and SQP algorithm for system variable configuration, the optimal effect for FCHV fuel economy is proven satisfactorily.

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