Optimum of Fuel Cell City Bus Power Train

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Abstract. Fuel cell power system have many advantages on the principle of energy conversion compare with the internal combustion engine. It is essential to optimum the fuel cell power system. In this paper, three different solutions of fuel cell city bus power system were analyzed and simulated with MATLAB. The power performance and fuel economy of the three different layouts were calculated and put forward the best design.

Introduction

Fuel cell power system is a new type of automobile power system that is potential to replace the traditional engine power system [1]. The way of its energy conversion is benefit for solving the problems caused by traditional internal combustion engine power system such as energy shortage and environmental pollution [2] [3].

Power System Layouts

The fuel cell in the system and the battery together provide energy to the drive motor. According to the power provided by the fuel cell accounted for the proportion of power travel required, the power train can be divided into different types [4].

The energy type drive system is shown as Fig.1. Fuel cell is connected to the motor controller through unidirectional DC/DC. The battery directly is connected to motor controller. To meet the demand of performance, the vehicle is equipped with large capacity battery [5].

The power type drive train is shown as Fig.2. Fuel cell is directly connected to the motor controller. Auxiliary power through bi-directional DC/DC converter indirectly connect to the motor controller. And the fuel cell provides the most power. But the battery is the auxiliary power. It works when the fuel cell starting, acceleration and climbing at the same time recycling energy during braking. So, the small battery capacity is chosen to reduce the weight of the vehicle to improve the power performance [5].
Super capacitor type uses a super capacitor instead of battery as the fuel cell hybrid system’s auxiliary power (Fig. 3).

Fuel Cell Bus Power System’s Simulation

SIMULINK Model of Fuel Cell Bus Power System

According to the design, the model of the SIMULINK model was constructed, as shown in Fig. 4.

Fig. 5 is the motor SIMULINK model. Fig. 6 is the battery pack SIMULINK model of the auxiliary power. The battery can recover the energy. However, the recycle energy can’t meet the output of energy, so when the battery energy is less than 80% of the total electricity, and when the fuel cell is not in a state of maximum output, fuel cell can charge the battery.
Fig. 7 is the battery pack SIMULINK model of the energy type power system. Fig. 8 is the battery SIMULINK model in this system. The battery output power is larger in energy hybrid power system.
The Simulation Results of the Fuel Cell Bus Power System

The fuel cell bus power system’s SIMULINK model for a 200 seconds of operation condition is shown as Fig.9. Fuel cell output power of the three types is shown as Fig.10. And the battery output power is shown as Fig.11.
Figure 9. Simulation mode.

Figure 10. Fuel cell output power.
According to the simulation results (Tab.1), we can know, the main energy provided by the fuel cell for the power type power system, and the battery provide only a little energy, the total value is 18950kJ. Fuel cell charge to the battery when the SOC of the battery is less than 80%, so the battery output and the input energy come into balance. The energy type has two power sources. And the total is 22800kJ. The power type can save more energy compared with the energy type, but it consumes less hydrogen because of the energy type fuel cell power system provides only half of the energy. And because of the battery provide a lot of energy, it cannot achieve energy balance. So, it need be charged. And because of the super capacitor recycling is high efficiency, the total energy output of the super capacitor type is 18280KJ. So, super capacitor type uses less energy among the three types.

|                     | Power type | Energy type | Super Capacitor Type |
|---------------------|------------|-------------|----------------------|
| Fuel cell output /kJ| 18000      | 12000       | 18000                |
| Auxiliary output /kJ| 950        | 10800       | 280                  |
| Total output /kJ    | 18950      | 22800       | 18280                |

Summary

Fuel cell bus power system were modelled in the paper by using MATLAB/SIMULINK. Through the simulation calculation analysis, we can know the characteristic of different power train. It is helpful to the design of the fuel cell city bus.

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