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Real-time Simulation Study for a Series Hybrid Electric Vehicle

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Abstract: To shorten design period and reduce development costs, computer modeling & simulation is important for HEV design and development. In this paper, real-time simulation for a Series Hybrid Electric Vehicle (SHEV) is made to test its fuzzy logic control strategy based on dSPACE-DS1103 development kits. The whole real-time simulation schematic is designed and the vehicle forward-facing simulation model is set up. Driver behavior is simulated by two potentiometers and introduced into the system to realize close-loop control. A real-time monitoring interface is also developed to observe the experiment results. Experiment results show that the real-time simulation platform works well and the SHEV fuzzy logic control strategy is effective.

Introduction

Effectively combining the advantages of traditional ICE vehicle and electric vehicle, Hybrid Electric Vehicle (HEV) can greatly improve fuel economy and reduce emissions at the same time, and it has become a research focus being paid much attention in recent years. In the design and development of HEV, computer modeling & simulation is one of its key technologies used to shorten design period and reduce development costs by testing configurations and energy control strategies before prototype construction begins [1,2].

According to the different information flow path, there are two kinds of HEV simulation. Backward-facing vehicle simulation takes the require/desired speed as an input, and determines what drivetrain torques, speeds, and powers would be required to meet that vehicle speed. This flow of information back through the drivetrain, from tire to axle to gearbox and so on Generally it only reflects the static properties of the system, and mostly used in vehicle design stage for parameter matching, dynamic performance calculating and control strategy determining.

Forward-facing vehicle simulation method includes a model of a driver, who senses the required speed and responds with an accelerator or brake position, to which the drivetrain responds with a torque. This type of simulation is well suited to the design of control systems, for example, down to the integrated circuit and PC card level—the implementation level. The simulation process in forward-facing is close to the real working process of the vehicle, and it can be used on the real-time simulation platform to achieve RCP (Rapid Control Prototyping) & HILS (Hardware-in-the-loop simulation), that is, the V-model development process [3,4].

Real-time simulation platform, such as dSPACE, builds a bridge between HEV control strategy and the vehicle model, through which real-time feedback from the vehicle to the control strategy in controller can be achieved. This may verify the effect of HEV control strategy designed in functional design and off-line simulation stage under an actual vehicle working conditions.

In this paper, a real-time simulation for a Series Hybrid Electric Vehicle (SHEV) is made to test its fuzzy logic control strategy using dSPACE real-time simulation platform. Firstly, a whole simulation schematic is given in section 1. And then the forward-facing vehicle model and its controller model are set up respectively in section 2 & 3. In part 4, vehicle & its controller model are downloaded into a dSPACE-DS1103 PPC controller board separately and real-time simulation experiments are performed. Finally conclusions are presented in section 5.

1. Real-time Simulation Schematic

The whole real-time simulation schematic is designed as fig.1 [5]. It mainly includes hardware and software two parts. According to the function requirements, it can be divided into vehicle (controlled object), controller, driver and monitoring 4 sub-modules.

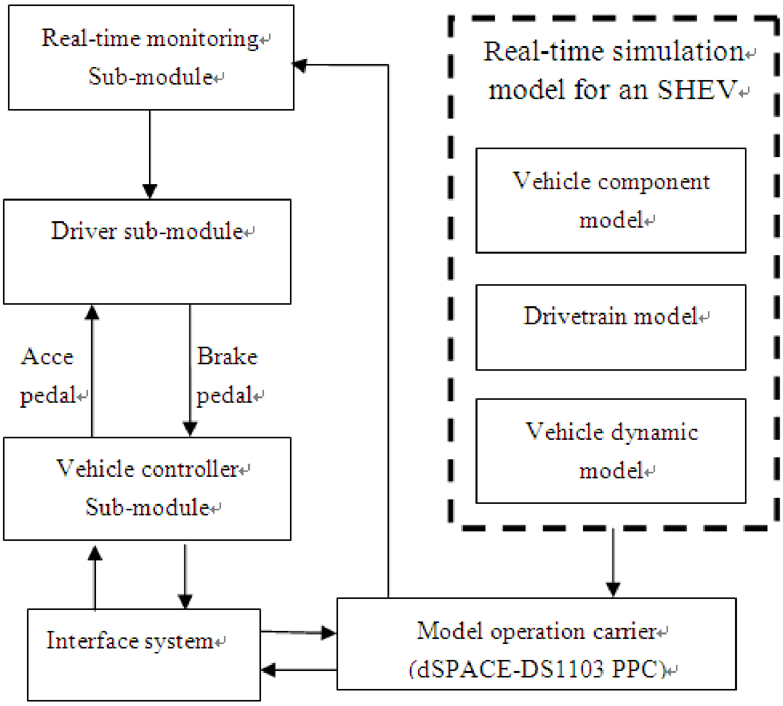

Fig.1 Real-time simulation schematic

2. Forward-facing Vehicle Model

A forward-facing simulation model is set up for the SHEV studied under MATLAB/Simulink environment as fig.2.

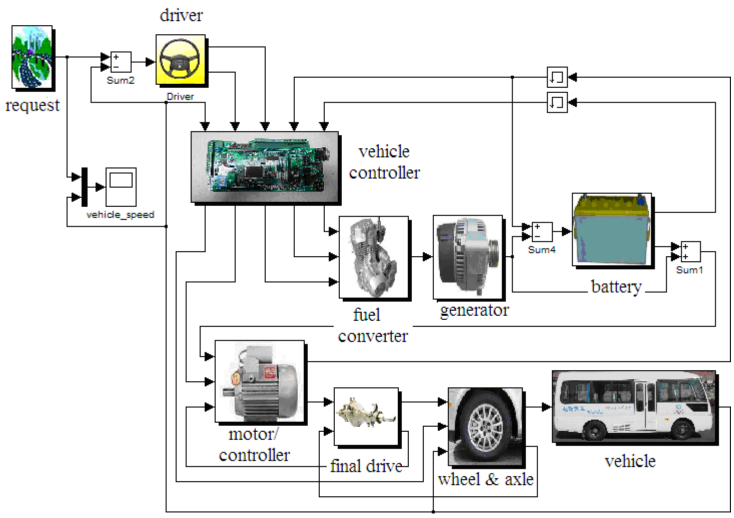

Fig.2 Forward-facing SHEV model

In fig.2, driver module passes acceleration and brake pedal signals to the controller according to the request speed (cycle speed) and the vehicle speed. It uses a PI controller to let the vehicle follow the request speed [6,7]. According to the pedal signals, controller uses the control strategy to split the power instantaneously. Vehicle speed information is given by the vehicle module and feedbacks to the driver module & controller module.

3. Controller Simulation Model

The controller model receives instructions from the driver model and detects the vehicle driving mode real-timely. According to the control strategy, the controller outputs signals to manage the energy/power flow from the different power components, so as to achieve coordinated & optimal control of the SHEV. The controller can be divided into 3 parts: torque demanded module, vehicle working mode switching module and fuzzy logic control strategy module. The fuzzy logic control strategy designed for the SHEV studied may realize constant SOC control, which is stated in reference [8-10]. The total vehicle controller simulation model is designed as fig.3.

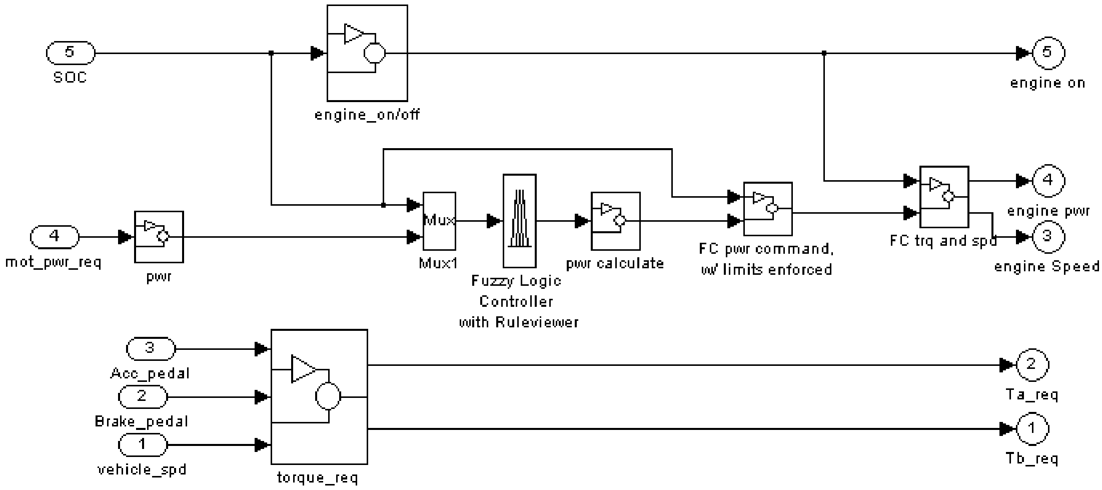

Fig.3 Vehicle controller simulation model

4. Real-time Simulation Experiment

4.1 Real-time simulation platform

In order to test the control performance of the fuzzy logic control strategy, it is very necessary to build a real-time simulation platform. In this paper, a dSPACE-DS1103 platform is chosen as the real-time operation carrier. The forward-facing vehicle model, as shown in fig.2, is divided into vehicle model & controller model, and both two models are packaged respectively. Real-Time Workshop (RTW) & Real-Time Interface (RTI) are used to convert the two simulation models into C code and downloaded into the DS1103 PPC controller board[11].

The vehicle model & controller model work separately in the DS1103 board. Communication between the two models is realized by using CP1103 panel to connect their I/O signals. DS1103 platform has abundant I/O resources, and different modules can communicate by set each module's I/O signals in respective channel, whose advantage is that the signal adjustment and interference may be don't care so as to enhance the system stability.

By using the dSPACE/ControlDesk software, a virtual real-time monitoring system is also developed. Through the monitoring interface can easily see the changes of every signal, and also can adjust the parameters by need. The interface is as fig.4.

Two potentiometers are used as the acceleration pedal and brake pedal to simulate the driver's behavior. Voltage range of the potentiometer is 0~5V, which corresponds to the pedal position signal, acceleration 0~1 & brake -1~0. Pedal signals are sent into the controller by connecting to CP1103 panel. By adjusting the two potentiometers manually, vehicle speed follows the given cycle speed.

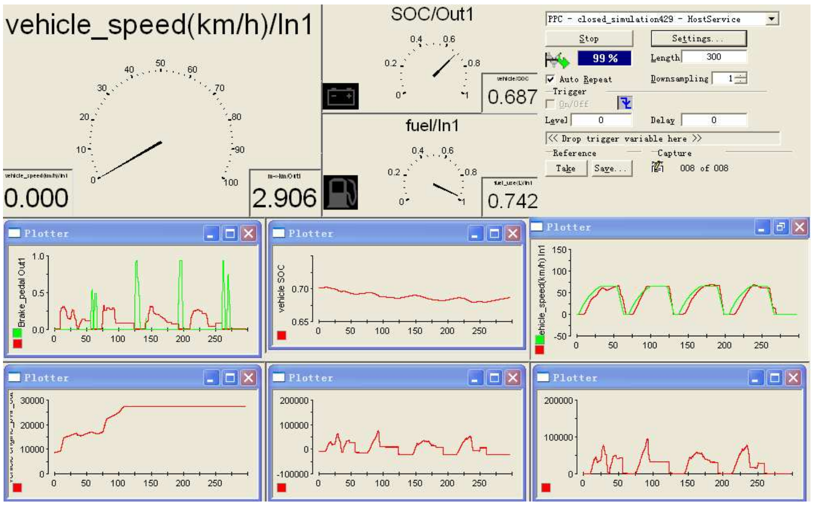

Fig.4 Real-time monitoring interface

The whole real-time simulation platform founded in this paper is as fig.5.

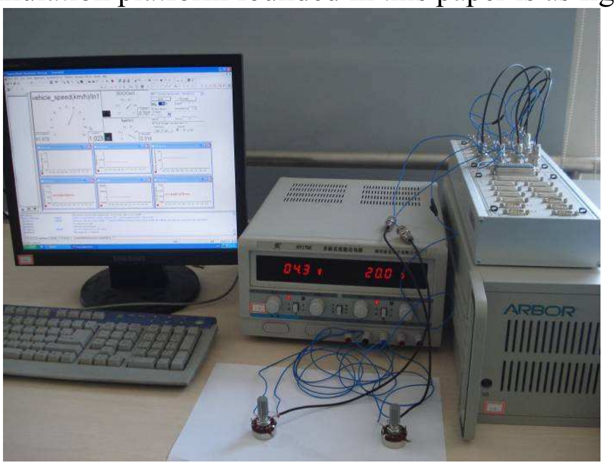

Fig.5 Real-time simulation platform

4.2 Experiment results

ARTERIAL is used as the driving cycle, and the real-time simulation results are shown in fig.6.

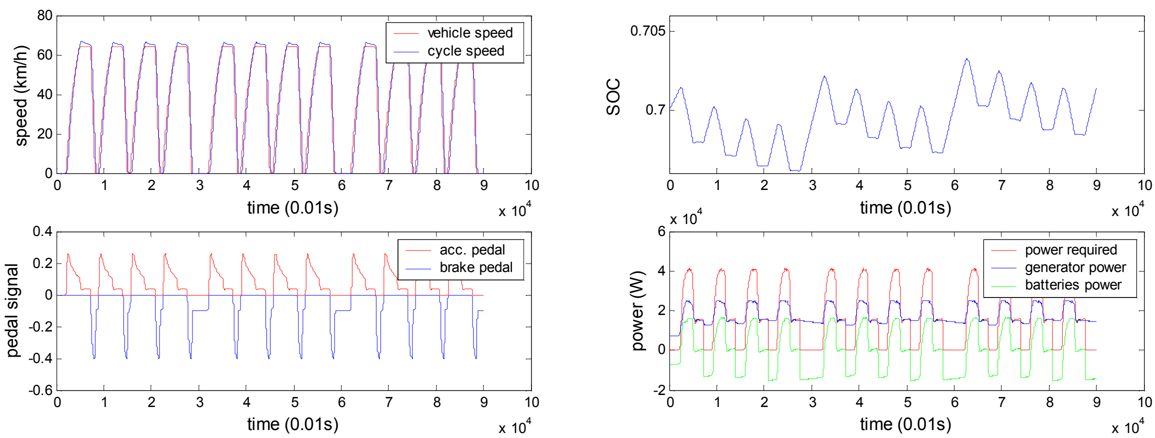

Fig.6 Real-time simulation results

From fig.6 it can be seen that, with the manual adjustment of the two potentiometers, the vehicle speed may follow the driving cycle well. Power output by APU changes following the power required by the vehicle. When vehicle power required is high, both the batteries and APU provide power; when it is low, APU decreases its output power and the batteries are charged. And SOC can be steadily working nearby 0.7 and realize constant SOC control of the fuzzy logic control strategy.

5. Conclusion

This paper introduces the real-time simulation work based on the dSPACE development platform for an SHEV. First the whole real-time simulation schematic is designed. And then a forward-facing simulation model is introduced. By using MATLAB/RTW & dSPCAE/RTI, the vehicle model & controller model are downloaded into a dSPACE-DS1103 PPC controller board separately. A real-time monitoring system is also developed to observe the experiment results. Using two potentiometers as acceleration pedal and brake pedal to simulate the driver's behavior, so as to achieve close-loop control. Finally the real-time simulation experiments are performed under ARTERIAL cycle. By manual adjusting the two potentiometers, the vehicle speed may follow the driving cycle well, which shows the real-time simulation system works well. The SOC changing curves also shows the fuzzy logic control strategy developed in the previous work is effective.

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References

[1] S. Sadeghi, J. Milimonfared, and M. Mirsalim. "Dynamic modeling and simulation of a series hybrid electric vehicle using a switched reluctance motor," *Proceedings of the International Conference on Electrical Machines and Systems*, Seoul, Korea, pp.2017-2022, Oct. 8-11, 2007.

[2] Guoqiang Ao, Jiaxi Qiang, and Ziqiang Chen, etc. "Model-based energy management strategy development for hybrid electric vehicle," *Proceedings of the 2008 IEEE International Symposium on Industrial Electronics*, Cambridge, Great Britain, pp.1020-1124, Jun.20-July.4, 2008.

[3] NREL. ADVISOR2002 Help Document.

[4] Xiang Zhang. "Research on the modeling and simulation of electric vehicle," *Postdoctoral Research Report of Hefei University of Technology*, Hefei, China, 2004.

[5] Yanping Wu, "Research on Control Strategies of Series Hybrid Electric Vhcilce," *Master's thesis of Beijing University of Technology*, Beijing, China, 2008. (In Chinese).

[6] Huang Miaohua, Chen Biao, and Chen Shengjin. in: *Driver's modeling and simulation in facing-forward simulation of electric vehicle [J], Journal of Wuhan University of Technology (Transportation Science & Engineering)*, Vol.28, No.6, pp.825-828, 2004.

[7] Li Jian, Yang Zhenglin, and He Huaqiang. In: *Study on forward-facing model for series hybrid electric bus [J], Journal of Machinery & Electronics*, No.12, pp.24-27, 2008.

[8] Xudong Liu, Yanping Wu, and Jianmin Duan, "Power split control strategy for a series hybrid electric vehicle using fuzzy logic," *Proceedings of the 2008 IEEE International Conference on Automation and Logistics (ICAL2008)*, Qingdao, China, pp.481-486, Sep.1-3, 2008.

[9] Xudong Liu, Yanping Wu, and Jianmin Duan, etc. "Constant SOC control of a series hybrid electric vehicle with long driving range," *Proceedings of the 2010 IEEE International Conference on Information and Automation (ICIA2010),* Harbin, China, pp.1603-1608, Jun. 20-23, 2010.

[10] Xudong Liu. "Research on the series hybrid electric vehicle control strategies and its application techniques," *Doctor's thesis of Beijing University of Technology*, Beijing, China, 2008. (In Chinese).

[11] dSPACE Ds1103 PPC Controller Board Hardware Installation and Configuration, 2006.

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