Research on Hybrid Electric Vehicle Control System and Energy Management

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Abstract: The energy crisis and environmental pollution are two major challenges facing the automotive industry. The development of energy-saving and environmentally-friendly vehicles has been linked to the country's sustainable development. Hybrid electric vehicles combine the advantages of both traditional and pure electric vehicles. They not only have the advantages of low fuel consumption and low emissions, but also have unlimited driving range, moderate price and suitable for industrialization. They are considered to be the most promising alternatives to the present car's solution, therefore, the research on the key technologies of hybrid electric vehicles has very important practical significance.

1. Introduction

With the accelerating urbanization process, the continuous increase of car ownership, the depletion of petroleum resources, and the deteriorating air quality caused by pollutants emitted by motor vehicles, the development of new vehicles with low emissions and low fuel consumption has become the development of automobiles in the world today. Urgent task. An electric car is an electric drive road vehicle. Electric vehicles include Electric Vehicle (EV), Hybrid Electric Vehicle (HEV) and Fuel Cell Electric Vehicle (FCEV), which are ideal for zero or low emissions. The vehicle has the advantages of no pollution, low noise, simple structure, convenient maintenance, etc., and can also utilize other non-oil resources such as coal, water conservancy, etc. Therefore, it is the most effective way to solve the problem. However, the battery of one of the key components of electric vehicles, such as energy density, life, price and other issues, makes the cost performance of electric vehicles can not compete with the traditional internal combustion engine. Fuel cell electric vehicles have high efficiency, low emission, low noise, fuels have a wide range of sources, and have significant advantages such as renewable. They have become the focus of fierce competition in the new century in the world. They are known as the 21st century. The top ten technologies that change human life, but industrialization still takes a long time. Under this circumstance, hybrid electric vehicles (HEVs) that combine the advantages of internal combustion engine vehicles and electric vehicles have become hot spots for new-type vehicle development worldwide, and have become a practical transitional solution for solving energy-saving and environmental protection problems.

2. Hybrid electric vehicle definition and drive type

A series hybrid electric vehicle consists of the main components of the engine, generator, battery pack, drive motor and controller. The engine is only used to generate electricity, the electric energy generated by the generator is supplied to the electric motor, and the electric motor drives the car to travel. The engine and the generator are integrated to form a system, that is, the auxiliary power unit. When the power generated by the engine exceeds the power required for the vehicle to travel, part of the power generated by the generator charges the battery to extend the mileage of the hybrid electric vehicle. In addition, the battery can separately supply electric energy to the electric motor to drive the electric vehicle, so that the hybrid electric vehicle runs under zero pollution. In a series hybrid electric vehicle, the electric energy generated by the generator and the electric energy output by the battery are output to the electric motor to drive the vehicle, and the electric motor is the only driving mode. Only the motor is directly connected to the transaxle (this is the same as a pure electric vehicle), and the engine is directly connected to the generator to generate electrical energy

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to drive the electric motor or to charge the battery. The driving force when the car is running is output by the electric motor, which converts the electric energy stored in the battery into mechanical energy on the wheel. When the state of charge (SOC) of the battery drops to a predetermined value, the engine begins to charge the battery. The engine is not mechanically coupled to the drive system, which greatly reduces the transient response of the vehicle to which the engine is subjected. The reduction in transient response allows the engine to perform optimal fuel injection and ignition control to operate near the optimum operating point.

Advantages of the series hybrid electric vehicle: (1) The engine can always be maintained in a sTable, high-efficiency, low-pollution operation state, and the harmful exhaust gas can be controlled to a minimum range, and other types of engines such as a gas turbine and a rotary engine can be used. (2) In view of the overall structure of the series hybrid electric vehicle, only the generator-motor power system is more similar to the electric vehicle. Several large component assemblies are placed on electric vehicles and will have a greater degree of freedom. Disadvantages of series hybrid electric vehicles: (1) The power of each component assembly is large, the shape is large, and the quality is also large. It is difficult to arrange on small and medium-sized electric vehicles. (2) In the energy conversion process of thermal energy-electric energy-mechanical energy in the engine-generator-motor drive system, energy loss is large. Therefore, the energy output of the engine output is lower than that of the internal combustion engine.

3. Key technologies for hybrid vehicles

Hybrid vehicles are a combination of traditional internal combustion engine and pure electric vehicles with advanced control technology. They cover a wide range of technologies, including electromechanical engineering, power electronics, electrochemistry, control engineering, automotive electronics and vehicle engineering. Many technologies of hybrid vehicles are common technologies of electric vehicles, such as electric drive systems, storage batteries and their management systems, vehicle control systems, etc. Even as a transitional model, it has important research and development value. The parameter matching of the hybrid system is an important part of the design of the hybrid vehicle. It includes reasonable selection and matching of engine power, power battery capacity and motor power to determine the hybridity of the vehicle and constitute the optimal hybrid drive system. . Since the power system has many different combinations and the parameter design has a large degree of freedom, computer simulation is an important means to match the parameters of the hybrid system.

Hybrid vehicles combine the advantages of both traditional and pure electric vehicles. They are the perfect combination of the two. The combination of this is the vehicle control system of the hybrid vehicle. The main function of the vehicle control system is to manage the vehicle energy and Control of the hybrid system. The vehicle control system, like the brain of a hybrid car, directs the coordination of various systems to achieve optimal efficiency, emissions and power, while maintaining the smoothness of travel. The vehicle control system judges the driver's intention according to the driver's operation, such as the accelerator pedal, the brake pedal, and the operation of the shift lever, and optimally distributes the power components such as the motor, the engine, and the battery under the premise of satisfying the driving demand. The power output enables optimal management of energy, allowing the limited fuel to perform at its maximum. At present, hybrid vehicles do not require external charging. Therefore, like conventional vehicles, the energy of a hybrid vehicle comes from the heat energy released by the fuel combustion of the engine. The electric energy required for the motor drive is the heat energy of the fuel. Stored in the battery after being powered. The goal of the energy management strategy is to make fuel energy conversion efficiency as high as possible. Fuel (material) energy conversion efficiency refers to the percentage of chemical energy (thermal energy) contained in fuel (material) through the power unit, energy storage device and drive train, which is ultimately converted into mechanical energy for driving the wheel. Vehicle energy management must be achieved by effectively controlling the operation of the hybrid system. In addition, energy management needs to consider the energy consumption of other vehicle electrical accessories and mechanical accessories, such as air conditioning, power steering, brake boosting, etc. Consumption, to consider the energy use of the vehicle.

The power battery is the basic component of a hybrid vehicle, and its performance directly affects the performance of the drive motor, thereby affecting the fuel economy and emissions of the vehicle. The performance requirements of hybrid vehicles for power batteries are very different from those of pure electric vehicles. In pure electric vehicles, the number of batteries is large, and the weight can account for 30% to 40% of the total weight of the vehicle. Therefore, the power density requirement of the battery is required. The battery capacity and capacity of the hybrid vehicle are much smaller, generally only 1/15 to 1/20 of the EV battery, so the battery has a large working load and requires high power density. Therefore, the power battery is generally divided into two types of high-energy batteries for EVs and high-power batteries for HEVs to meet the different requirements of HEVs and EVs for batteries. In addition, the SOC (State of Charge) operating range of the HEV power battery is narrower, and the cycle life requirement is much higher than that of the EV battery. Currently, the power batteries commonly used in hybrid electric vehicles are lead-acid batteries, nickel-hydrogen batteries, and lithium-ion batteries. Lead-acid batteries are the cheapest, but have low energy density and are being replaced by two other types of batteries. Lithium-ion batteries have the best performance, but with the increase of power, the cost will increase sharply. At the same time, the safety of high-power lithium-ion batteries is more prominent. Therefore, it is mostly used in mobile phones and notebook computers and less in automobiles. From the current situation, the power battery for hybrid vehicles is mostly nickel-hydrogen batteries.

4. Control strategy

Hybrid vehicles use two forms of energy to provide driving for the entire vehicle. The key question is how to develop the energy supply and conversion control system based on the working conditions, that is, the development of the power control system. This is the core content and technical difficulties of hybrid vehicle development. Hybrid vehicle control systems should improve fuel economy and reduce emissions by coordinating control of each assembly under the premise of meeting the vehicle's dynamic performance. From the form of energy management strategy implementation, it can be divided into the following four types:

It is a control strategy that limits the operating range of the engine and battery to a high efficiency range by setting thresholds to limit the engine operating range. The most common is the electrically assisted control strategy. In this control strategy, the motor is used as a flexible factor in the power system, and the engine output power is “cut peak-filled“ according to the vehicle working conditions to optimize the operation of the engine. The main conditions are as follows: 1) The motor is driven separately when the car needs to be powered up or the vehicle speed is lower than a certain threshold. 2) The engine is running at a certain speed. When the torque demand is less than the corresponding minimum engine torque, the engine will be shut down and the required torque will be supplied by the motor. 3) The engine is running at a certain speed. When the torque required by the vehicle powertrain is greater than the maximum torque that the engine can provide, the motor provides auxiliary torque and is driven in conjunction with the engine. 4) When the battery is charged, that is, the SOC is too low, the engine will provide additional torque to the motor. The motor operates in the form of power generation to generate electricity for the battery. 5) During the regenerative braking process, the motor works in power generation mode, and the recovered energy is fed back to the battery pack. When the battery SOC state is higher than the minimum SOC state allowed, if the vehicle speed is lower than the minimum speed, the engine does not work, the vehicle driving power is provided by the motor, the car works in pure electric state, the fuel consumption and emissions are 0; when the vehicle speed is higher than the minimum At the speed of the vehicle, if the torque at this time is smaller than the specified engine torque, it is also driven by the motor, and the engine is not allowed to work at low speed and low load to reduce fuel consumption and emissions.

The logic threshold control strategy algorithm is simple, easy to implement, and has good robustness. It is the control strategy commonly used in hybrid vehicles. But in theory, the static control strategy is not optimal. Moreover, since the threshold value of this control strategy has been set in advance and is a fixed value, it has poor adaptability to operating conditions and parameter drift, and it only limits the engine to operate in a higher efficiency zone, and is provided by the motor. The remaining power does not take into account the efficiency of the motor.

5. Conclusion

This paper focuses on the development of the hybrid car vehicle project, focusing on the design of the vehicle controller and several advanced energy management strategy design methods. The vehicle controller and multi-work mode switching control strategy of the parallel hybrid car designed in this paper have been applied to the actual prototype and verified by road test.

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