Optimization Research on Automobile Energy Recovery System

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Abstract: Brake energy recovery technology is an important technology for the research and development of electric vehicles and hybrid electric vehicles. The maximization of energy recovery efficiency has also received extensive attention and attention. However, there are few researches on the optimization of automotive energy recovery systems. Recycling structural form and basic working principle, discussing a braking energy recovery control strategy based on hybrid energy storage system, hope to help the car energy recovery efficiency to maximize.

1. Introduction

With the continuous development of automobile technology, energy conservation and emission reduction have become the two main areas of concern. The traditional automobile brake system converts kinetic energy into heat energy and then dissipates it. The brake energy recovery system converts part of kinetic energy. For other forms of energy to be stored and reused when needed, it is advantageous in terms of vehicle emission reduction and can create huge social benefits. Part of the energy that was originally wasted is recovered through the vehicle energy recovery system, which also contributes to the improvement of economic efficiency. At this stage, more and more hybrid models are popular among consumers, and electric energy has become the main source of power for automobiles. Applying the energy recovery system to hybrid vehicle braking can effectively help the car to reduce power consumption, and can also reduce the thermal load and wear of the brakes, thereby improving the energy efficiency and safety of the hybrid vehicle. The brake energy recovery system plays a very important role in the automobile, and it is necessary to conduct in-depth research to make a greater contribution to energy saving and emission reduction.

2. Research status of automobile energy recovery

It is not difficult to see that energy recovery is a very important technology, and many scholars have carried out related research. From the perspective of foreign research, Yimin Gao proposed three power distribution control strategies for evaluating the recovery efficiency of braking energy, and constructed an active energy simulation experimental model for pure electric vehicles, and conducted a pilot experiment on different braking strengths [1]. Yimin Gao and Mehrdad Ehsani proposed a pure electric vehicle and a hybrid vehicle based on a braking energy recovery system [2]. Wicks studied the energy-saving effect of the regenerative braking system by establishing a mathematical model of the city bus under the condition of losing driving cycle [3]. Domestic scholars started late in this aspect. From the perspective of vehicle testing, Zhang Yan and other scholars put forward indicators for the recovery and recovery efficiency of braking energy of pure electric vehicles, and based on the test data, the NEDC conditions of three EV models. The braking energy recovery efficiency under the measurement is measured [4]. Li Hongliang and others have responded to the best dynamic response of the flywheel energy storage in the braking energy feedback process. A new type of flywheel is combined with the power supply system, and the principle test of braking energy feedback is carried out by constructing a small test bench. The test results show that the energy feedback efficiency can reach 33% [5]. Comprehensive research shows that there are many researches on the energy recovery of automobiles in domestic and foreign scholars, but there are few researches on the optimization strategy of this system. This paper takes this as a starting point and hopes to enrich the research theory and optimize the energy recovery

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system for automobiles. Practice provides benefits.

3. The basic principle of automotive energy recovery system

The basic working principle of the automobile energy recovery system is shown in Figure 1. When the vehicle is decelerating, the energy conversion device connected to the transmission system converts the kinetic energy of the vehicle into another form of energy and stores it, releasing the energy when needed. . The brake energy recovery system is an important technology for hybrid and pure electric vehicles, and is also an important feature of these two models. When the internal combustion engine car is decelerating and braking, the kinetic energy of the vehicle is converted into thermal energy by the brake system and released to the atmosphere [6]. The braking energy recovery system in hybrid vehicles and pure electric vehicles can convert this part of the thermal energy released into the atmosphere into electrical energy and store it in the vehicle battery, thereby transforming into energy that can help the car drive. Take the car start or acceleration as an example. At this time, a larger driving force is needed to start or accelerate. The braking energy recovery system can provide auxiliary power to the engine through the motor driving force. At this time, the electric energy stored in the vehicle battery is stored. Can fully play its role.

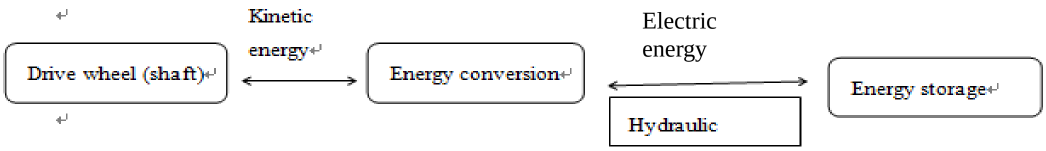

Figure 1 Schematic diagram of the car energy recovery system

Typically, approximately one-fifth of the energy of a vehicle under normal braking without emergency braking can be recovered through an energy recovery system. Brake energy recovery varies according to the way the hybrid power works. When the engine valve of the car does not stop, the energy that can be recovered by the car deceleration is about one-third of the energy of the vehicle. The valve is stopped by the intelligent valve timing and lift control system. The mechanical friction of the engine itself can be reduced by about 70%, and the recovery energy is increased by two-thirds of the vehicle's energy.

4. Automobile energy recovery system structure

The energy storage form of the automotive brake energy recovery system includes flywheel energy storage, hydraulic energy storage and electrical energy storage.

The energy storage process of the flywheel is mechanical energy converted into mechanical energy. The energy loss is low during the conversion process and the conversion efficiency is high. The brake energy recovery system has a simple structure, but has many shortcomings, mainly reflected in the large size and large mass of the flywheel, which is not easy to arrange. The fuel consumption is increased, the flywheel needs to meet the requirements of high-speed dynamic balance, and the manufacturing cost is high; due to the existence of the rotational resistance, the energy stored by the flywheel is gradually reduced, which is not suitable for long-term energy storage.

The working process of the hydraulic energy storage system is: when the car breaks or decelerates, the traditional system drives the hydraulic pump to work. The hydraulic pump converts the low pressure oil into high pressure oil and stores it in the accumulator. The energy stored by the accumulator when the car starts or accelerates Used to drive the car. The hydraulic energy storage system is flexible in layout, high in power density, and the stored energy is not reduced. The energy density of hydraulic energy storage is low, and the sealing requirements of components are very high. In addition, the development of highly efficient reversible hydraulic pumps is difficult.

The electric energy storage system refers to a power generation device connected to the power train that converts the kinetic energy of the vehicle into electric energy, stores it in the energy storage device, and releases the electric energy when needed. Mainly used as accumulators are chemical batteries and super capacitors. Although the electric energy storage has low power density, the structure is simple, the control is convenient, the storage energy is durable and reliable, and the comprehensive performance is good. With the development of highly efficient motors and batteries, electrical energy storage energy recovery systems are becoming more widely used.

Table 1 Structure and advantages and disadvantages of automotive energy recovery system

Automotive energy recovery system structure	Advantage	Disadvantage
Flywheel energy storage system	Low energy loss, high conversion efficiency, and simple structure	Not easy to arrange and fuel consumption, high manufacturing cost, not suitable for long-term energy storage
Hydraulic energy storage system	Flexible layout, high power density, and reduced storage energy	Low energy storage energy density, high requirements on component sealing, difficult to develop
Electric energy storage system	Simple structure, convenient control, long-lasting and reliable storage energy, high comprehensive performance	Low power density

5. Optimization design of automobile energy recovery system

5.1 Hybrid Energy Storage System

A new hybrid energy storage system is proposed, which is mainly composed of a hybrid power supply, a DC/DC converter, an H-bridge inverter and a brushless DC motor, which can be connected in series and parallel switching. When the car is in driving condition, the battery is the main power source, and the super capacitor group is the auxiliary power source; when Chen Liang is in the feedback braking condition, the super capacitor bank is used as the main energy storage unit for recovering braking energy, and the battery pack is changed to assist the energy storage unit.

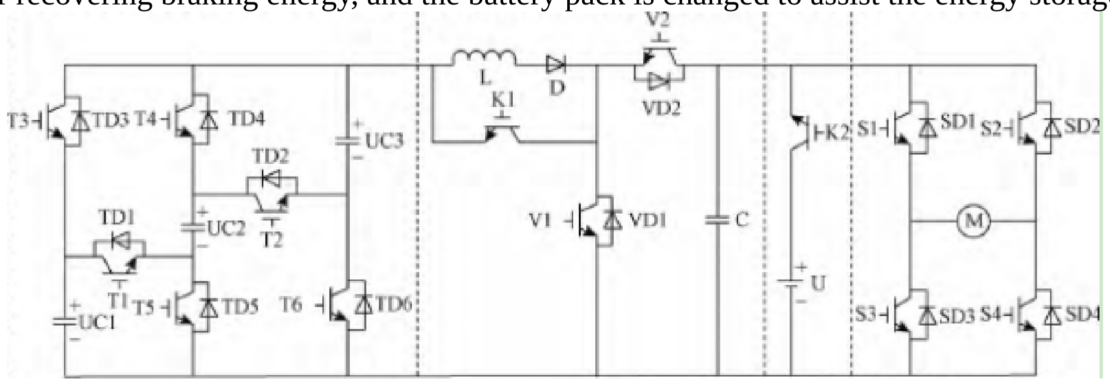

Figure 2 Hybrid power storage system consisting of a new super capacitor bank and battery

The drive control process of the energy storage system is as follows:

(1) When the vehicle starts, the vehicle has a large power demand for the hybrid energy storage system. The control K2 and V2 are disconnected, T1 and T2 are turned on, V1 is controlled by the PWM signal,and there are three series connected super capacitors to boost the independent power supply.

(2) When the vehicle accelerates or climbs the slope, the vehicle has a large power demand for the hybrid energy storage system, the control V2 is disconnected, K2, T1, T2 are turned on, and V1 is controlled by the PWM signal, which can realize the super capacitor box and the battery. Parallel power supply, where the battery provides the average power portion and the super capacitor

provides the peak power.

The braking energy recovery control process of the energy storage system is as follows:

When the vehicle brakes or travels downhill, the motor is in a feedback braking state and the electric motor operates as an engine. When the induced electromotive force generated at both ends of the generator is greater than the parallel voltage of the super capacitor module, the controls K1, T3, T4, T5, and T6 are turned on, the ultra-capacitor group can be realized to recover electric energy in parallel. The induced electromotive force generated by the motor winding decreases as the vehicle speed decreases. When the induced electromotive force is equal to or lower than the voltage of the parallel super capacitor bank, the engine no longer feeds back energy to the super capacitor.

5.2 Brake Energy Recovery System Optimization Strategy

The braking energy recovery control strategy of the new energy storage system proposed in this paper is optimized based on the ideal braking force distribution strategy and optimal braking energy recovery control strategy. The key to this control strategy is to ensure the braking stability and braking comfort of the vehicle, and to maximize the braking energy recovery efficiency. Under normal braking conditions, the electric brake is prioritized, and the vehicle brake is decelerated or stopped as much as possible by electric braking; in the case of emergency braking, hydraulic braking is prioritized.

Therefore, under the premise of ensuring the safety and stability of electric vehicle braking, the following control strategies are proposed:

(1) For small-intensity braking ($z\leq0.1$), it is possible to control only the motor to provide braking force, where z is the braking strength.

(2) During normal braking ($0.1<z\leq0.7$), under the conditions of ECER13 regulations, the front and rear axle braking forces should be properly distributed, and the external characteristics of the motor and the state of charge (SOC) should be considered. Conditions such as state, priority electric braking, to maximize the recovery of braking energy.

(3) During emergency braking ($0.7<z$), the maximum recovery braking force is preferentially provided by the motor. The insufficient part is compensated by the hydraulic braking force. If the front and rear wheels are locked, the ABS starts immediately and gradually reduces the electric braking force. At the same time, the hydraulic braking force is increased, and the degree of power reduction of the electric mechanism is consistent with the degree of increase of the hydraulic braking force.

(4) If the super capacitor bank has remaining power S_{OC} <80%, the electric energy is preferentially recovered to the ultra-capacitor group. If the super capacitor bank has remaining power S_{OC} ≥80%, to ensure the safety of the ultra-capacitor bank, the energy recovery to the ultra-capacitor group is stopped. And recover energy from the battery. If the super capacitor bank has remaining power S_{OC} <20%, the discharge is stopped and the battery is charged to the ultra-capacitor bank.

(5) When the motor speed is too low, the recovery voltage generated by the motor is lower than the voltage across the ultra-capacitor bank and the battery pack after the chopper is stepped down, and the braking energy recovery process ends. The principle of the control strategy is that the driver steps on the brake pedal, and the pedal stroke and pedal speed can be obtained through the pedal simulator to obtain the driver's braking intention and braking strength. At the same time, the ECU brake controller according to the current vehicle speed and battery power, and according to the motor External characteristics, the braking force of the front and rear wheels is distributed, and the electric-liquid braking state is controlled according to the above strategy to realize braking energy recovery. Compared with the conventional braking energy recovery system, the hybrid power supply composed of the series and parallel switching ultra-capacitor group and the battery can improve the vehicle power and economy, and the optimized electric-liquid compound braking control strategy can improve the braking. Among them, by controlling the charge and discharge circuit, three power supply modes and two brake energy recovery modes can be realized.

The advantages of the braking energy recovery control strategy proposed in this paper mainly include: Under different braking strength and vehicle speed conditions, coordinated control of electric braking and hydraulic braking can be realized, and the braking force control mode is optimized; Under the control of the braking energy flowing to the ultra-capacitor group, not only the protection of the battery can be realized, but also the voltage of the super-capacitor after the parallel connection is lower, the braking energy can be fed back in a wider speed range, and the braking energy recovery rate is improved.

6. Conclusion

Flywheel energy storage, hydraulic energy storage and electrical energy storage are the main structural forms of automotive energy recovery systems. They have different advantages and disadvantages. They are used in different designs, and a new hybrid energy storage system is selected and optimized. It not only guarantees the braking stability and braking comfort of the vehicle, but also maximizes the braking energy recovery efficiency, which is the purpose of the optimized design of the energy recovery system.

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