Modeling and Simulation Analysis of Control Strategy for Electric Vehicle Energy Recovery System Based on Computer

Xianhuan Wu*
Wuhan Business University, Hubei, China, 430056

*E-mail: 1954226161@qq.com

Abstract. With the increasingly serious environmental problems, electric vehicles are becoming more and more popular. The major factor restricting the further development of electric vehicles is the limitation of driving range. Therefore, it is of great significance to study the energy recovery technology of electric vehicles. At the same time, with the increasing maturity of computer technology, it also provides us with more research methods. This paper first introduces the principle of energy recovery system and regenerative braking control strategy of electric vehicle based on computer. Secondly, computer modeling software is used to model the control strategy of braking energy recovery of electric vehicles. Finally, simulation software is used to analyze the model.

Keywords: Simulation Analysis, Control Strategy, Electric Vehicle Energy Recovery System

1. Introduction

With the serious problem of environmental pollution, the environmental protection policies of various countries are more and stricter, which makes the traditional automobile manufacturers start to electric layout, directly promoting the rapid development of the electric vehicle industry\(^{(1)}\). In addition, due to the advantages of new energy electric vehicles such as high efficiency and low pollution, it has become the future development direction of traditional fossil fuel vehicles\(^{(2)}\). However, at present, there are still many shortcomings of electric vehicles, such as short endurance mileage, imperfect charging facilities and long charging time, which directly limit the further popularization and development of electric vehicles\(^{(3-4)}\). Braking energy recovery of electric vehicle can effectively extend its endurance mileage, improve energy efficiency and further reduce energy consumption. As the recovery of braking energy of electric vehicles conforms to the concept of energy conservation and emission reduction in environmental protection, it has become one of the hot spots in the recent research of electric vehicle technology, which has important practical significance for promoting the future development of electric vehicles\(^{(5-6)}\).
2. Principle of energy recovery system of new energy electric vehicle

2.1. Types of new energy electric vehicles

At present, new energy electric vehicles can be divided into EV, HEV, E-REV and FCEV is not only different from the traditional vehicle in power device, but also in driving mode, structure mode and technical principle.

![Figure 1. Types of new energy electric vehicles](image)

2.2. Energy recovery theory of electric vehicle regenerative braking

The braking capacity recovery system of electric vehicle should meet two functions: on the one hand, it should realize the braking function of vehicle, which can reduce or stop the vehicle speed safely; on the other hand, it can realize the energy recovery by converting the braking kinetic energy of vehicle deceleration into electric energy stored in the power battery. The effect of the forces indicated during braking of the vehicle is shown in Figure 2 below.

![Figure 2. The forces indicated during braking of the vehicle](image)

Among them, \( T_u \) is the braking torque; \( F_{sb} \) is the horizontal braking force provided by the ground to the wheel; \( W \) is the vertical load of the wheel; \( F_Z \) is the normal reaction force of the ground to the wheel; \( T_P \) is the horizontal thrust of the axle on the wheel. According to the moment balance relationship in the
wheel force analysis diagram, the road braking force can be obtained as follows:

\[ F_{xb} = \frac{T_u}{r} \]  

(1)

The braking force of the road depends on the braking force of the brake and is limited by the adhesion conditions of the road. If the road adhesion is good, when the brake force increases, the road braking force increases, so as to achieve good braking effect. The relationship among road braking force, brake braking force and road adhesion is shown in Figure 3. Where \( F_\phi \) is the road adhesion and \( \phi \) is the road adhesion coefficient.

![Figure 3](image)

**Figure 3.** The relationship among road braking force, brake braking force and road adhesion

### 2.3. Basic principle of vehicle braking energy recovery

The regenerative braking energy recovery of automobile is to convert the kinetic energy of automobile into electric energy and at the same time use the reverse torque generated by motor as the braking torque of vehicle to slow down the automobile. The essence of braking energy recovery is to generate current charge by cutting magnetic field through induction circuit, so as to realize vehicle braking and make energy recovery device store energy. In addition, in order to ensure safety, the vehicle kinetic energy brake recovery system also needs to be used in combination with the traditional brake system, so as to ensure the safety of emergency braking and other special use cases. This composite braking mode is realized through the motor and hydraulic braking system.

### 3. Control strategy of regenerative braking for electric vehicle

#### 3.1. Control strategy of electric vehicle regenerative braking

At present, the control strategies of regenerative braking mainly include braking force distribution control strategy, braking energy recovery control strategy and regenerative braking force distribution control strategy, as shown in Figure 4. No matter which regenerative braking control strategy, its control core is to solve the problem of braking force distribution.
3.2. Limited conditions of braking energy recovery for electric vehicles

The process of braking energy recovery of electric vehicles will be affected by many factors, such as driving resistance, braking force, battery characteristics and the selected braking control strategy. In addition, part of the braking energy will be lost and dissipated in the form of thermal energy during the braking process. For example, the braking energy generated at the driven wheel cannot be recovered, and only part of the braking energy at the driving force can be recovered. Therefore, the braking energy that can be recycled and reused only accounts for a small part of the total braking energy.

3.3. Technical factors

In the current new situation of economic operation, technology is used more and more in the organization. As one of the important parameters in the evolution of hotel group organization system, technology can dominate the behavior of organization system, and bring more and greater innovation space to business model. The business model chosen by the hotel industry is closely related to its technical means. The application of technology in the hotel industry is mainly its reservation and payment system, as well as the construction of related network platform. The advanced technology application is directly related to the user experience. But on the other hand, if the technology application is too radical, it will bring more challenges to its business model, such as the corresponding improvement of organizational management level and service level. Therefore, a comprehensive balance is needed to consider the relationship between the two.

4. Modeling of brake energy recovery control strategy for electric vehicles

4.1. Identification and modeling of braking intention

In the process of electric vehicle braking energy recovery, while part of energy is recovered to the battery energy storage system, the motor will also provide the braking force required by braking to play the braking role to ensure safety. In addition, the driver's braking intention is also the key of braking control strategy, and directly affects the recovery of braking energy. Generally speaking, there are three cases of braking intention: small strength braking, medium strength braking and emergency braking. As the driving state of the vehicle is dynamic and very complex, so the action of the moving pedal reflects the

Figure 4. Control strategy of electric vehicle regenerative braking
main factors of the driver's braking intention. Therefore, the fuzzy recognition method is used to identify the braking intention.

4.2. Modeling of braking energy recovery control strategy

The input parameters are vehicle speed, braking intention, motor torque and other variables. The output parameters are load signal and friction braking pressure. The selected strategy model is fuzzy control and motor torque calculation module. Based on the calculation of vehicle speed and braking intention, the motor load signal corrected by the correction module is obtained through the output of the fuzzy control module.

5. Simulation analysis of braking energy recovery system

According to the above evaluation indexes of braking energy recovery, evaluate the effect of braking force distribution strategy of braking energy recovery system, and get the simulation analysis results under different braking conditions, as shown in Figure 5 below.

![Battery recovery energy under different braking condition](image)

**Figure 5.** Battery recovery energy under different braking condition

From the simulation results in Figure 5, it can be seen that the energy recovery value is large and the energy recovery efficiency is high. The selected braking force distribution strategy can be effectively applied to the vehicle braking energy recovery system.

6. Conclusion

The driving form, battery performance, control strategy and working condition of electric vehicle will directly affect the braking energy recovery efficiency of electric vehicle. The simulation results show that the control strategy model designed in this paper can ensure the effective energy recovery of vehicles.

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