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ANALYSIS OF THE RECOVERY SYSTEM BRAKING ELECTRIC VEHICLES.

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Abstract– Electrically powered vehicles are a relatively new industry in the automotive world today. The first electric cars, which were created in the early stages of development in the automotive industry, had much-improved characteristics in relation to cars running on internal combustion engines. Over the years, the development of technologies for producing fuel for internal combustion engines has become significantly more affordable and much cheaper, as a result of which the need for electric vehicles has significantly decreased. At the beginning of the 21st century, environmental degradation due to exhaust emissions from internal combustion engines of cars gave a new impetus to the development of electric vehicles [1]. This article is devoted to the analysis and evaluation of the use, as well as the effectiveness of the regenerative braking system of electric vehicles.

Key words– Electric car, regenerative system, brake system, ecology, transport.

I Introduction

Using the conventional braking system of classic cars on electric vehicles is not very effective for the braking system of an electric vehicle. When braking with classic brake pads, mechanical energy is converted into thermal energy. The use of a regenerative system in electric vehicles makes it possible to save part of the energy during braking, which can be stored in batteries and later used for electric drive. Thereby the range of the electric vehicle on one charge increases. Such braking can also save wear on the friction linings in the brake system, which increases their service life. Based on the above, this study is relevant. [2].

This issue was dealt with by such scientists as Dembitsky V.M., Kashuba A.M., Le V.N., Dam P.H., Nguyen C.H., Kharitonchik S.V., Kusyak V.A. [3, 4, 5]. Having examined the works [3, 4, 5], one can see the effectiveness of using recuperation systems on electric vehicles, which save the electrical energy of the traction battery.

The purpose of the article is to identify the types of braking systems that can be used in electric and hybrid vehicles, as well as to analyze them.

II MAIN PART

Electric vehicles and hybrid electric vehicles have two braking systems: a conventional one with friction brakes and a regenerative braking system.

In a conventional brake system, the pads or friction brakes are driven by a hydraulic drive, in which hydraulic fluid is supplied under pressure to the brake cylinders, which operate the brake mechanisms.

Regenerative braking is the process of returning part of the energy for reuse in the same technological process. Brake energy regeneration, or energy regeneration during deceleration, significantly increases the range of any electric vehicle. In new models of electric vehicles from BYD, Volkswagen, Tesla, Toyota and many other companies, this concept is aimed at ensuring maximum energy efficiency [6].

A description of the main components of the regenerative braking system of a modern passenger electric vehicle driven by the front axle is shown in Fig. 1.

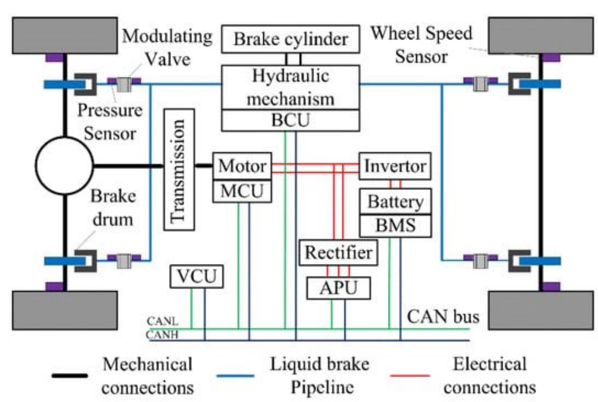

Fig. 1: Diagram of an electric vehicle's regenerative braking system. [7]

As shown in Fig. 1, the braking system of an electric vehicle consists of two systems: a hydraulic braking system and an electric braking system. In a hydraulic brake system, the pressure in the master wheel cylinder can be adjusted using modulating valves. Each wheel is equipped with modulating valves. Each wheel can be controlled independently by a hydraulic brake controller [7].

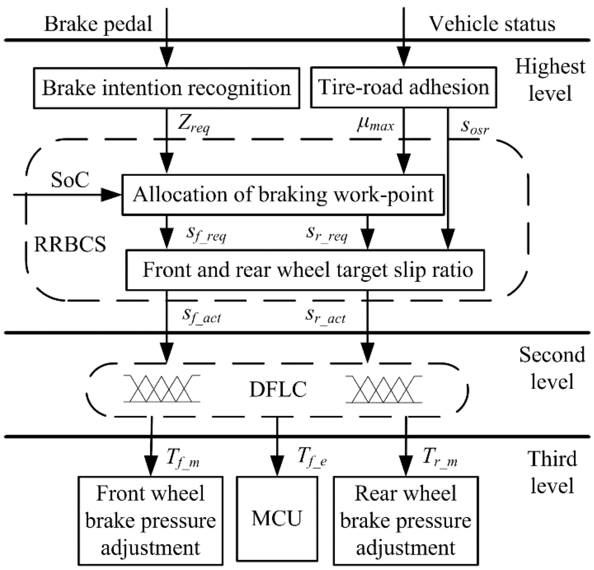

Fig. 2: Control level of the revised regenerative braking control strategy (RRBCS). [7]

The revised regenerative braking control strategy (RRBCS) studied in this paper was divided into three levels: the highest level (regenerative braking controller), the second level (fuzzy controller), and the third level (actuator), as shown in Figure 2.

At the top level are the hydraulic braking controller and the electrical controller in the regenerative braking system (RBS), whose main task is to coordinate the regenerative braking torque and the hydraulic braking torque. The second level contains a double fuzzy logic controller (DFLC), which differs from the fuzzy controller in [8,9,10,11]. In addition, it can adjust the braking torque in real-time to control the slip ratio of the front and rear wheels to ensure that the target slip ratio is well maintained. The third level includes a regenerative-hydraulic braking system without a controller, the task of which is to implement the braking process under the control of the controller.

When the brake pedal is activated, the regenerative system initially comes into play, which replaces the friction braking system by creating artificial resistance to wheel rotation through an electric drive which works in the generator mode. The effective maximum braking torque of a traction motor in generator mode depends not only on the strength of the excitation current but also on the armature speed, which in turn depends on the speed of the electric vehicle. Thus, braking efficiency varies depending on the driving speed. If the traction motor does not provide sufficient braking efficiency, the difference between the level of efficiency set by the driver and the one created by the electric motor is compensated by the friction braking mechanism.

The higher the high-voltage battery charging current produced by the electric motor in generator mode, the greater the braking force. Regenerative braking control is achieved through joint control of the braking system and transmission. In this control, the regenerative braking system and the hydraulic braking system combine their efforts, taking into account fluctuations in the parameters of the regenerative system caused by the battery charge or vehicle speed. As a result, it is possible to minimize the loss of kinetic energy.

The extraction of electricity during braking of electric vehicles represents a significant source of reducing energy consumption in an electric traction system. The modern technological base also allows you to smoothly adjust the braking force until the vehicle comes to a complete stop. This reduces emissions of harmful substances into the environment resulting from mechanical braking and increases driving comfort and safety.

A vehicle design using electric braking with energy recovery requires virtually no additional braking system. However, the vehicle is actually still equipped with a hydraulic braking system. Thus, the braking process of a vehicle with an electric motor, in addition to the conventional system with friction braking mechanisms, is complemented by another component - electric braking, which increases the active safety of the vehicle.

Today, there are two types or categories of regenerative braking systems, the definition of which is given in European regulations [11].

1. Category A – electrical regenerative braking system, which is not part of the service braking system;
2. Category B – electric regenerative braking system, which is part of the service braking system.

These two categories of braking systems differ mainly in the way they are activated. A Category A regenerative braking system is activated when the accelerator pedal is released, while a Category B regenerative braking system is activated when the accelerator pedal is moved to the zero position and the service brake is applied. In the case of category B regenerative braking system, the electric motor typically generates electrical energy while coasting.

The main problem is that over long distances the efficiency of using the regenerative system is practically negligible, since the car is mainly in acceleration mode, and braking is only a small part of the time. This reduces the efficiency of braking energy recovery, making battery charging less efficient and making the electrical system more complex. Therefore, regenerative braking is widely used in hybrid vehicles, where it has achieved approximately 30% savings in the total energy required to drive the vehicle.

III CONCLUSION

As a result of the study, the author came to the following conclusion: Thus, the use of a regenerative system in electric vehicles increases their economic and environmental performance, and also increases the service life of the high-voltage battery by optimizing the processes of regenerative braking, starting the traction motor and charging the battery.

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