Research on New Automotive Electronic Hydraulic Brake System

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Abstract. The new structure of EHB replaces part of the mechanical transmission by electronic control, brake pedal is not connected with brake wheel cylinder directly. While braking, ECU collect the sensor signal of brake pedal as the driver’s intention. It solves the problems caused by traditional hydraulic braking system, and also makes up for deficiencies caused by the traditional braking system design and principle. The EHB system can make brake control gets the maximum control margin, which can improve the efficiency and braking safety.

1. New EHB Braking System

Figure 1 is a composition diagram of an intelligent EHB braking system. The system includes an electronic control unit ecu, a brake pedal sensor, a hydraulic pump, a backup valve and brake actuators. During brake operation, the hydraulic connection between the brake pedal and the brakes is broken, and the backup valve is closed. The ECU can judge the driver’s braking intention through the sensor signal, and the hydraulic pump is driven by the motor to brake. Then it uses the sensor on the electronic pedal to drive the pedal induction simulator to simulate the human foot feedback force during braking. The system has a dual redundant design. When the electronic system fails, the backup valve will open and the EHB system will become a traditional hydraulic system. The backup system increases the safety of the braking system and makes the vehicle’s online control system fail. It can be braked, but the existing backup system still contains complex brake fluid transmission pipelines, making EHB not a complete brake-by-wire system product.
2. Working principle of New EHB Braking System

Figure 2 is the component architecture of EHB system. It is mainly composed of four parts: brake pedal unit, hydraulic drive unit, brake execution unit and control system. The control system is to collect vehicle system information, including wheel speed sensor, steering wheel angle sensor, yaw angle speed sensor, pedal travel sensor, wheel cylinder pressure sensor, etc. These signals are transmitted to the input port of the single-chip microcomputer after the conditioning module. After the unit machine performs calculations and logical judgments based on the collected information, it becomes a control signal to control each solenoid valve and after the power is amplified, the hydraulic pump motor is controlled. The hydraulic pump motor will establish the pressure of the hydraulic pump, and the established pressure will be input into the high-pressure accumulator.

The stages of work are as follows:
2.1 Initial state:
Figure 3 is the description of Initial state about EHB. The left 1 solenoid valve is normally closed, the left 2 solenoid valve is normally open, and the right 1 is normally closed. Because the person has not stepped on the brake pedal to establish pressure, the ESC has not established pressure in any of the wheel cylinders.

2.2 Human controlled braking state:
Figure 4 is human controlled braking state of EHB system. If a person steps on the brake pedal at the front end of the brake cylinder, if the medium pressure is established, the ecu of ESC can control the hydraulic pump motor to establish the pressure of the hydraulic pump based on the speed of the person’s pedaling and various sensor information. The left 1 solenoid valve is input to the booster cavity. Because the pressure of the booster cavity is established, the wheel cylinder can generate a greater pressure than the human pedaling, and the boost mode is realized, so that the vehicle can slow down. And because the right 1 solenoid valve is opened, Making people's consciousness of pedaling directly causes the pedal feel simulator to generate feedback on human consciousness.

2.3 Energy feedback braking state:
Figure 5 is energy feedback braking state of EHB system. If people step on the pressure, if the medium demand pressure is established, the braking force generated by the drag force of the motor is sufficient to ensure the safe driving of the vehicle. Therefore, the left 1 solenoid valve is not opened. Because the left 1 and left 2 solenoid valves are not opened, so the cylinder cannot generate enough pressure to brake by itself, and the current braking force still comes from an external braking source. However,
the opening of the right 1 solenoid valve will make people feel that the vehicle is being controlled by
the feedback pressure generated by the pedal feel simulator.

2.4 Brake by wire state:
Figure 6 is brake by wire state of EHB system. If a person does not step on the brake pedal to generate
pressure, the vehicle senses that it needs to brake at this time. The ecu of ESC will control the
hydraulic pump motor to start, building up the pressure in the hydraulic pump, and the established
pressure will pass the left 1 electromagnetic valve is input to the booster cavity, and the pressure in the
booster cavity is established to implement the boost mode to make the vehicle decelerate. Because the
right solenoid valve 1 is not opened, the pedal feel simulator does not give feedback to the brake foot.

2.5 Principle of pedal feel simulator:
Since the pedal feel simulator can directly change the pedal foot feel generated by a person stepping
on the brake pedal, and can directly change the feedback of the brake feel of the person, its function is
extremely important for the person's experience. Its main function is to Arbitrary adjustment of the
pedal feel allows the pedal to be actively adjusted by a solenoid valve in a small range, which can also
greatly reduce the holding torque. Figure 7 is the characteristics of pedal force simulator.
2.6 Principle of improving energy recovery efficiency:
When the driver's required torque is determined, the feedback torque of the motor will also be actively generated. If the generated feedback torque cannot meet the driver's braking requirements and the vehicle's deceleration requirements, hydraulic braking will increase. The part that makes up for the shortcomings makes the vehicle slow down according to the driver's needs. Figure 8 shows the principle:

3. New EHB Features and Benefits
The new ehb structure introduced in this article can not only avoid the technical monopoly of existing products of foreign auto parts, but also combine the current Chinese characteristics and existing
domestic technologies to achieve rapid market entry. At the same time, this structure can also be used in light-weight Hydraulic brake trucks have been applied. Currently, many cities prohibit large trucks from entering urban areas, and the main force of logistics in that city falls on light trucks, and current urban environmental protection requirements, many urban light trucks have been replaced with new energy light trucks.

Using the new EHB structure can mainly generate value in the following points:

1. The system can comply with Pedestrian and vehicle safety regulations; It can help vehicles to get higher deceleration; Also it can bring more security features.

2. Environmental protection and fuel economy; Low loss, low braking lag brings high endurance mileage; Reduced parts and weight; More and more vehicles without powered vacuum sources are on the vehicle, Increased energy recovery efficiency.

3. Intelligent driving; Active remote control is an essential feature for smart driving.

The differences and advantages of the new EHB structure compared to the products launched by other international component giants:

1. Since Bosch launched ibooster as EHB product. The system uses a non-absolute decoupling method. When the human and linear control are acting simultaneously or energy is recovered, because of the non-absolute decoupling method, the braking foot feel and the control range of the linear control are stepped on by people. The impact of the mechanical braking pressure generated during the pedaling process brings problems such as a bad experience and limited energy efficiency. Even the braking force generated by the machine is too slow and the drag force is generated. Safety may even cause premature wear of the brake pads. However, this structure also has the advantage that when the brake pedal is artificially depressed, even if the linear control fails or the control fails to achieve the effect, the mechanical mechanism produced by its artificial consciousness Motivation can still make up for it.

2. The IBC system introduced by ZF and Continental, its brake execution function, brake booster and control system (ABS and ESC) are integrated into a small lightweight brake module. Because it is a highly integrated mechanism In order to achieve fast response and build pressure, a high-efficiency, high-speed motor is required. For the time being, domestic motors are still making breakthroughs in this motor. In addition, the domestic automotive chassis electronic control system ESP / ESC is not very mature. And in the period of large-scale application, it is not easy to directly apply such a highly integrated product.

4. Conclusion

Vehicles have higher and higher requirements for braking performance. Traditional braking systems have limited potential for improving braking performance due to structural and principle limitations. The electronic hydraulic braking system (EHB) as a new type of braking system makes up for the traditional The deficiency of the braking system can greatly improve the braking performance of the vehicle.

With the increase of high-grade highways and the increase of the average vehicle speed, how to make high-speed vehicles perform braking deceleration safely and stably in the shortest braking time and braking distance, which has become an urgent need to be resolved. The braking system is a guarantee for the safety of the car. After decades of development and research, a variety of braking systems have been developed and put into use in real vehicles, and relatively satisfactory results have been achieved. Due to the limitation of structure and principle, even if an anti-lock braking control system such as abs is added, the maximum optimal braking force control cannot be achieved. This also proposes the necessity for us to develop the next-generation braking system. In the future with a large number of applications, the development of EHB will become a delay. It replaces some mechanical components with electronic components, the brake pedal is no longer directly connected to the brake wheel cylinder, and the driver's operation is collected by sensors as the control intention. The brake operation is completely completed by the hydraulic actuator, which makes up for the deficiencies
caused by the traditional brake system design and principle, so that the brake control has the greatest degree of freedom, thereby making full use of the road adhesion, improving braking efficiency.

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