Research on Control Unit of Motor Drive Brake Actuator

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Abstract. It can be said that the core of car safety is the car brake and its control system. Along with the development of the car, the car brake and its control system has undergone many changes, from rubber friction braking solely relying on manpower to the later pneumatic brake system, hydraulic brake system and so on. Among them, the hydraulic brake system is the most widely used. With the continuous advancement of technology, electric drive machines are widely used in vehicles. Research on electric power assisted hydraulic brake systems has become a hot research topic in recent years, as autonomous driving and driverless. Essential and key components are the inevitable trend and the best solution for the next generation of automotive braking systems. This study describes a control unit for a motor-driven brake actuator that analyzes its role, structure, and advantages in an electric-assisted hydraulic brake system.

1. Intelligent brake boost system

Figure 1 is a composition diagram of an intelligent brake boosting system, including a control unit (1), an electric brake actuator (5) and a vehicle stability assisting device (9). The control unit (1) being connected to an electric brake actuator (5). The electric brake actuator (5) is also connected to the vehicle stabilization aid (9).

The intelligent brake boosting system is driven by a motor, controlled by an ECU, and can be mounted on an autonomous driving vehicle, which is a future development trend.

2. Control unit functions

2.1. Control unit structure

The control unit (1) is mainly composed of three parts: the pedal master cylinder (10), the pedal force simulator cylinder (11), and the ECU (12).
1. Controller; 2a. Output port one; 2b. Output port two; 3a. Output port three; 3b. Output port four; 4. Oil cup output port one; 5. Electric brake actuator; 6. Oil cup output port two; 7. Output port six; 8. Oil cup output port three; 9. Vehicle stability auxiliary device;

Figure 1. Intelligent brake boost system components

1. Controller; 10. Pedal master cylinder; 11. Pedal force simulator cylinder; 12. ECU; 13. Piston one; 14. Piston two; 15. Simulated cavity piston;

Figure 2. Control unit structure

Piston one (13) and piston two (14) divide the pedal master cylinder (10) into two chambers, namely chamber I, chamber II, wherein chamber I is in communication with chamber III.

The controller (1), the electric brake actuator (5) and the vehicle stability assisting device (9) are connected by a hydraulic circuit formed by a hose or a pipe.

As shown in Fig. 3, the chamber II output ports 2a, 2b of the controller (1) and the chamber II output port of the electric brake actuator (5) are connected to point c, and then connected to the vehicle stabilizing aid (9). The chamber I output ports 3a, 3b of the controller (1) are connected to the cavity I output port of the electric brake actuator (5) at point d, and are then connected to the vehicle stabilizing aid (9).

The pressure sensor Pm and the normally open solenoid valve A2 are sequentially connected to...
the connecting line of the chamber II to the output ports 2a and 2b, and the normally open solenoid valve A2 is in the open position when the power is not supplied.

A normally open solenoid valve A1 is sequentially connected to the connecting line of the cavity I to the output ports 3a, 3b, and the normally open solenoid valve A1 is in the open position and a pressure sensor Pp when the power is not supplied;

The cavity I is in communication with the cavity V, and a normally closed solenoid valve A3 is mounted on the connecting line thereof, and the normally closed solenoid valve A3 is in a closed position when not energized;

**Figure 3. Principle of intelligent brake boost system**

2.2. **How the control unit works**

The working method of the intelligent brake boosting system control unit, the method comprises the following steps:

*Step S1:* When the driver steps on the pedal, as shown in FIG. 2, the piston one (13) is pushed to the left by the transmission of the ball joint link, and the magnetic ring mounted on the piston one (13) moves along with the left side. As shown in Fig. 3, the Hall displacement sensor (17) mounted above the magnetic ring on the cylinder detects the change of the magnetic field of the magnetic ring and transmits the signal to the electronic control unit (ECU), which is received by the electronic control unit (ECU). The signal is processed and the signal is output to the electric brake actuator (5).

*Step S2:* The electric brake actuator (5) receives the control signal sent by the control unit (1), compresses the cavity i, the cavity ii through the internal motor transmission device, and outputs the brake fluid to the vehicle stability auxiliary device (9), the vehicle stability assist. The device (9) then implements the braking function by calculating the brake device that distributes the brake fluid to the various wheels of the vehicle.

*Step S3:* At the same time, when the brake pedal is depressed, the piston (13) is pushed to the left. In the power state, the normally open solenoid valves A1 and A2 are in the closed state, and the normally closed solenoid valve A3 is in the open state. Because the cavity I is connected to the cavity...
III, the brake fluid of the cavity I is pressed to the cavity III, the analog cavity piston (15) is pushed to the right, and the spring device inside the cavity IV is compressed by the analog cavity piston (15) when the pedal. The deeper the step, the greater the amount of displacement of the brake fluid (15) to the right by the brake fluid, and the greater the spring force generated by the spring device inside the chamber IV. The reaction force sequentially passes through the simulated cavity piston (15), brake fluid, the piston (13) and the brake pedal are transmitted to the driver, so the deeper the reaction is depressed, the greater the pedal force experienced by the operator.

**Step S4:** The brake pedal is released, the brake is released, and the electronic control unit (ECU) on the control unit (1) causes the motor drive device in the electric brake actuator (5) according to the signal of the Hall displacement sensor (17). The rotation chamber i, the chamber ii is reversely rotated, and the brake fluid is returned to return the electric brake actuator (5) to the initial state.

**Step S5:** At the same time, the brake pedal is released, the cavity I space of the control unit (1) is released, the internal pressure is reduced, the brake fluid is returned from the cavity III to the cavity I, and the control unit (1) is gradually restored to the initial state.

When the electric brake actuator (5) fails, the control unit (1) acts as a safe hydraulic brake actuator. At this time, the normally open solenoid valve A1, the normally open solenoid valve A2, and the normally closed solenoid valve A3 are all in a power off state.

The normally open solenoid valve A1 is turned on, and the control unit (1) output ports 3a, 3b output brake fluid to the vehicle stability assisting device (9).

The normally open solenoid valve A2 is turned on, and the controller (1) output ports 2a, 2b output brake fluid to the vehicle stability assisting device (9).

At this time, the normally closed solenoid valve A3 is closed, and the pedal force simulator cylinder (11) has no brake fluid input, and does not function.

The control unit of the motor-driven brake actuator described in this study can be used as both a collection pedal input signal and a hydraulic brake actuator that is insured when the electric brake actuator fails.

### 3. Advantages of the control unit

The control unit of the motor-driven brake actuator of the present invention has the following positive effects:

3.1. The control unit of the motor-driven brake actuator can be used as a device for collecting pedal input signals, outputting signals for controlling the electric brake actuator, and at the same time it is a hydraulic brake actuator that is insured when the electric brake actuator fails.

3.2. When the brake pedal is depressed, a reaction force is applied to the brake pedal through the simulator piston, brake fluid and master cylinder piston. The deeper the reaction force is, the more the reaction force is generated, and the brake force is generated by the operator. 

3.3. Hall sensor is used to collect the displacement signal, and the signal acquisition is fast and sensitive.

3.4. A pressure sensor is set on the pipeline to collect the pipeline pressure and feed it back to the ECU, which has closed-loop adjustment control function.

3.5. The components are highly integrated, and have the advantages of light weight, few parts and small volume compared with the traditional vacuum booster.

### 4. Conclusion

Compared with the traditional hydraulic brakes, the intelligent brake boosting system has made significant progress, which improves the braking efficiency and makes the control convenient and
reliable. Compared with the same type of products on the market, the intelligent brake boosting system has long life, high reliability, strong environmental adaptability, reduced user maintenance cost, economic benefits, and meets the needs of the OEM to reduce costs and increase efficiency.

As an important part of the intelligent brake boosting system, the control unit can be used both as a collection pedal input signal and as a hydraulic brake actuator when the electric brake actuator fails. In particular, its fail-safe capability is trusted by car manufacturers.

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