Parking Brake Breaking-In Technology Based on EPB

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Abstract When the parking brake shoes are installed, it must be initialized with Breaking-in process, in order to meet the parking performance requirements, especially the independent parking brake. This article describes a vehicle dynamic Breaking-in technology for independent parking brake, based on electronic parking brake system.

Keywords EPB · Break-in · After service · DIH · EOL

1 The Necessity of Breaking-In Process for Independent Parking Brake

The new installation of the brake friction plate cannot be fully fit and brake surface, because of its irregular surface and mounting structure reasons. Initial friction plate efficiency will be low; resulting in vehicle brake performance does not reach the goal, when the friction joint area is too small. As shown in Fig. 1:

To solve this problem, the Breaking-in process will increase friction plate joint area in braking. The Breaking-in, or Running-in, is the process of sliding friction under pressure between friction materials and brake disc or drum. The joints area will increase while the irregularities of the friction materials are polishing. Braking efficiency will continue improving in Breaking-in.

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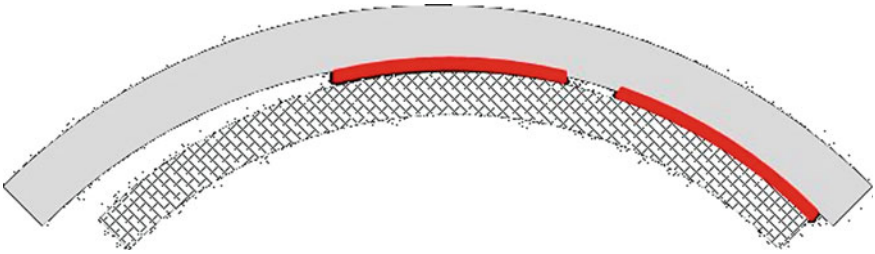

Fig. 1 The indication of friction plate joint surface

For service brake, Breaking-in process can occur in vehicles moving. Depressing the brake pedal, the friction lining will be abraded in wheels rolling and it will improve the braking efficiency continuously [1, 2]. However, for the parking brake, it only works in static mode generally, and the working frequency is far less than the service brake, so it cannot be Break-in in application of conventional. If the initial braking efficiency is unqualified, the parking brake may not provide enough parking force in slope. It will cause the risk. Therefore, the friction plate, shared by parking brake and service brake, can be used without special Breaking-in. But the independent friction plate for parking brake, such as Drum in Hat (DIH), is very necessary to be Break-in. (See Fig. 2)

2 The Conventional Mechanical Handbrake Breaking-In

There are two methods to Break-in the conventional mechanical handbrake, which connecting to DIH.

2.1 Parts Breaking-In

The first method is approach named "parts Break-in", after parking brake is assembled with shoes and drum together. There is a Breaking-in equipment to ensure the parking brake is acceptable. Then the parking brake assembly can be sent to the vehicle assembly process. In this way, the consistency of the vehicle parking performance can be ensured at equipment, but the costs will be higher from the equipment construction and operating. In addition, this method isn't applicable for lining replacing in after service. It is not worth to replace entire "well-done" parking brake, if it only because abrasion of the friction plate.

Fig. 2 Independent parking brake and service brake

2.2 Vehicle Dynamic Breaking-In

The second Break-in method is "vehicle dynamic Breaking-in". New car off the assembly line can be Break-in when moving in a low parking force, similar to service brake process. When mechanical handbrake to be pulled up the appropriate latch number, can make the parking brake force not only maintaining the friction plate to joint, but also to ensure that force not big enough to locking wheel completely. So choosing the appropriate parking force is important conditions fit the dynamic Breaking-in.

When you select the appropriate Breaking-in parameters, you can also ensure the consistency of braking efficiency in batch after Breaking-in. The dynamic Breaking-in process can be finished in wheel revolving test equipment to fit vehicle factory. It can also be done on the testing road, so it can meet the demands of factory and after service at the same time.

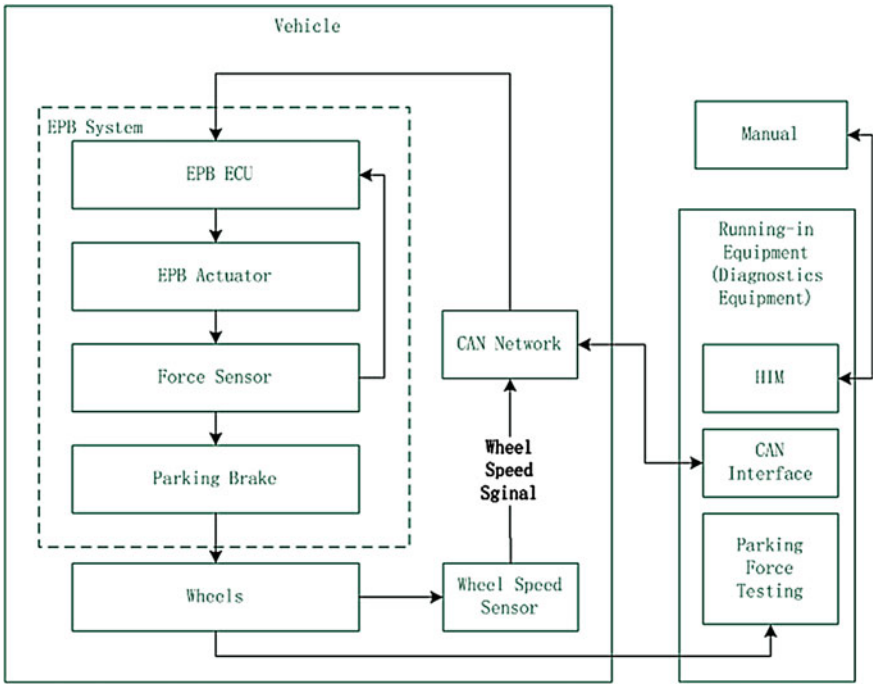

Fig. 3 Electronic parking breaking-in system hardware architecture

3 The Electronic Parking Brake Breaking-In

Electronic parking brake system (EPB), which is different from the mechanical handbrake, users can not choose the parking force free. When the vehicle static parked, the biggish force will completely lock the wheels, and the vehicle will be difficult to accelerate. So it's unable to complete the dynamic Breaking-in.

EPB started brake when vehicle moving, will enter an emergency mode called "dynamic braking". After rapid deceleration, the vehicle will be stopped eventually. The wheel does not roll, so amount of Breaking-in will not meet the requirements. In order to achieve Break-in effect, it must be repeated using the "dynamic braking" mode to Breaking-in by repeating acceleration and deceleration cycles. But by this method, each Breaking-in amount is limited, and cannot be precise cumulative. Process is difficult to control and count manually, with the huge workload and low efficiency.

Therefore, the EPB system function, similar to the mechanical hand brake, can select the appropriate parking force and perform the vehicle dynamic Breaking-in. An efficient Breaking-in system need to precisely control the amount of Breaking-in. Amount of Breaking-in is defined in the following:

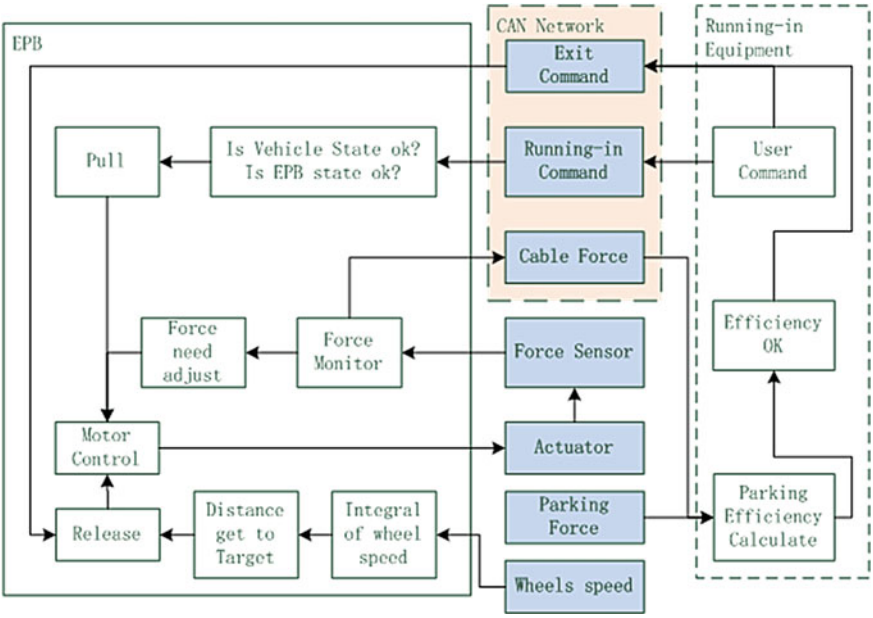

Fig. 4 Detailed description following

$$A = k \times F \times L$$

A Amount of Breaking-in
F Force of Breaking-in
L Distance of Breaking-in.

The following hardware structure can be obtained running the force and distance (Figs. 3, 4):

In this figure, the equipment can get the parking force from wheels. Breaking-in equipment is any diagnostics equipment adding Breaking-in software.

4 The Breaking-In Process

The function of different part in Breaking-in system

Breaking-in equipment sends a target to EPB ECU, and monitors and controls the Breaking-in process. At the same time, equipment can also be receiving commands from operator.

EPB ECU is responsible for controlling the actuators, precise control of the force of the parking and calculation of the running distance.

Exit Breaking-in processes

(a) Breaking-in distance

The running distance calculated by the EPB ECU, integrating the wheel speed to distance value by signals from CAN network. EPB will automatically quit Breaking-in and release parking brake when distance reach or exceed the distance target.

(b) Through the brake efficiency:

Running equipment receives real-time cable force from EPB ECU and continues testing parking force to calculate the real-time parking brake efficiency. When the parking efficiency monitored by equipment is greater than target, the equipment will send command to the EPB to exit Breaking-in.

c) The Breaking-in process can be manual intervention to exit to face special unknown situation.

Confirmation of Breaking-In Effect

Exit (a) is an open-loop control, according to the parameters set, it can be ensured that all vehicle match Breaking-in parameters. But all vehicles should pass the parking force testing process, as same as handbrake; Exit (b) is a closed-loop control, Breaking-in at the same time to detect the efficiency of parking. Therefore, after the end of the Breaking-in process, all vehicles can meet the objectives. Due to individual differences of brakes, every brake need different Breaking-in distance to fit to parking efficiency. The target distance of Breaking-in is the longest one, in order to meet all vehicles. So Exit (b) can save time.

Development of new car model

For different vehicles or brake, we only need to add a new Breaking-in parameters. There is no need to change the ECU or equipment software logic.

5 Breaking-In Parameter Settings

1. Breaking-in force F

As refer earlier, the right Breaking-in force, which maintaining friction plate to joint and not lock the wheels, is important. We can get a range from vehicle test. Sometimes we choose a big one, to reduce the distance of Breaking-in.

2. Parking Brake efficiency η

We need calculate the target of qualified parking brake efficiency.
The definition of the parking braking efficiency:

$$\eta = K \times (F_P \div F_C)$$

F_P Parking force;
F_C Cable Force

We set efficiency (η_F) the perfect fully Breaking-in shoes as 100 %, and get the ratio of "F_P" and "F_C" from vehicles which are perfect fully Break-in. then we get constant K.

Then we can get target efficiency (η_T) from the vehicle performance target. For example, we need park at slope of 20 % when cable force below 800 N. Any vehicle meet or over target efficiency can be set passing.

3. Breaking-in distance L

This technology is based on distance accumulating and force controlling.

Based on Breaking-in force has been selected and qualified efficiency goals, vehicle calibration test by vehicles of a quantity can get the range of Breaking-in distance. The maximum one in all samples should be choose.

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