

Design and Testing of a New Electric Parking Brake Actuator

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ABSTRACT

Electric parking brake (EPB) system provides the roomy space for vehicles compared with traditional handbrake system. Combining a control unit realizes the intelligent functions, which make vehicles more convenient and secure, and avoid the vehicle damage and danger caused by the negligence of drivers.

This paper provides a new concept design of the EPB system that has simple and low-cost characteristics. The testing results have proved the feasibility of this design. First we describe the working principle of this new design, and then introduce the arrangement of the testing system, followed by the discussion of experimental data. The last is conclusion paragraph.

INTRODUCTION

The intelligent function of EPB systems makes the parking brake be operated and released automatically. That is more convenient to use than traditional systems, and has the following merits:

1. Use an operation button to replace a hand lever.
2. Because of no hand lever, the vehicle has more spacious space.
3. Combining a control unit, EPB system can be automatically operated and released at the right time, which makes the operation simpler and the driver feel more comfortable and safe.

There are two types of existing EPB. One is the cable puller, and the other is the caliper. This new concept design belongs to the cable puller type. Many design concepts of the cable puller type use the ways of two cables [1,2]. Some perhaps use one cable to connect by way of the balancer one divides into two brakes [3]. Minorities also use the design concept of one cable method [4,5], which has small curvature radius of cable that will reduce the cable life and mechanical efficiency. The new concept design of this paper will also use one cable to connect two sides of the parking brake, but still maintain the cable life and mechanical efficiency.

Benchmarking - In table 1, there are four products of cable type EPB comparing with the new design concept. The important differences are shown as follows.

- No force sensor lets EPB be simpler and cost less.
- No balancer lets EPB be easily assembled on vehicle.
- No inner cable combine interface lets EPB reduce the production cost and assembly processes.
- Self-balance feature is useful to reduce difference of two side cable-pulling force.

Therefore, this new design concept has benefits such as without inner cable interface, simple structure, low cost, and easy assembly.

Table 1. Four products of cable type EPB comparison.

Cable type EPB	 [6]	 [7]	 [8]	 [9,10]	New Design concept
Supplier	ADVICS	Continental	Continental	DURA	-
Force sensor	Yes	Yes	No	No	No
Balancer	No	No	Yes	Yes	No
Inner cable combine interface	Yes (integrate balancer)	Yes (integrate balancer)	Yes	Yes	No (One cable only)
Self-balance	Yes	Yes	No	No	Yes

At present only some specific high price vehicles use the EPB system. But according to EPB system market's tendency report [11], the global EPB system's market demand will exceed 9 million sets in 2012; the revenue will reach 3500 million dollars.

SYSTEM DESIGN CONCEPT DESCRIPTION

It is not difficult to control an EPB. The mechanism is the key point of EPB system. The important factors that need be considered include:

- Cable-pulling force.
- Parking brake force can be maintained when the power source of electric motor is off.
- Working time of the actuator.
- The force for two sides of parking brake is near.

Actuator parts - The schematic drawing of actuator prototype is shown in Figure 1a. It comprises a brush motor, a pair of screw pole and six reduction gears, and uses one cable and two cable tubes to connect to two sides of brake. The prototype picture is shown in Figure 1b. The length, width and height of this box are 15cm, 10.5cm and 7cm. The volume is approximately 40% smaller than market products [12].

Working principle - This actuator uses one cable only, and two sides of cable connect brakes separately. When the electric motor rotates clockwise, it actuates the reduction gears (process 3 section reduction), and then propels the inner screw pole to rotate. When the inner screw pole rotates, it will actuate the outer screw pole and the guide tube, and then the right cable tube will move to right side, (the outer screw pole, guide tube and right cable tube are fixed as a combination.) Therefore, It will cause the cable tube to provide force to cable to pull the two sides of brakes. Cable-pulling force achieves balance in pulling process, and then keeps the vehicle motionless when it is parked. When the parking brake need be released, the motor reverses and the cable-pulling force will disappear. The principle that can make the cable have large curvature radius will maintain the cable life and mechanical efficiency. Besides, without a cable balancer, it has fewer inner interfaces for the cable, which provides characteristics of simple structure, low cost and easy assembly.

Force control method – To control cable-pulling force to keep the vehicle motionless when it is parked is our target. The control method of actuator belongs to close loop control. The controller uses feedback from the current sensor to control the motor. When the feedback motor electric current reach set value, the controller cuts off the power source. As the motor power source is off, the screw pole set has self-locking effect, and then the cable-pulling force will be retained. Using a current sensor instead of force sensor brings benefits of low cost and saving volume.

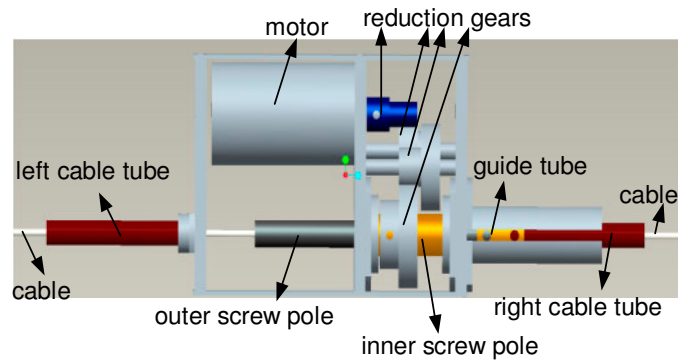


Figure 1a. The schematic drawing of actuator prototype

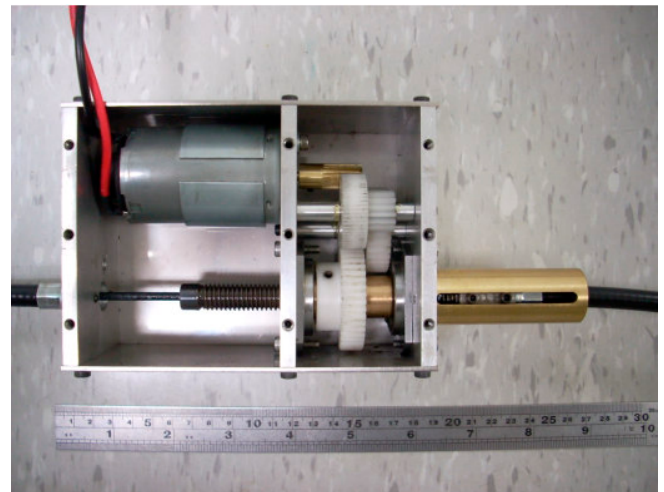


Figure 1b. The prototype picture.

TESTING EQUIPMENT

Testing equipment - The testing equipment of this new concept design prototype includes the following:

- A rigid fixed platform.
- A power supply (maximum : DC 60V/30A).
- A Notebook.
- A control unit of motor.
- Two load cells (5 KN).
- Two amplifiers of load cell.
- A data recorder.