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SIMULATION AND EXPERIMENTAL STUDY OF A NEW ELECTROMECHANICAL BRAKE WITH AUTOMATIC WEAR ADJUSTMENT FUNCTION

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ABSTRACT–This paper presents a novel electromechanical brake (EMB) with automatic wear adjustment function, which has been ignored in most previous studies. With the aim of investigating the parameter characteristics of the EMB system and analyzing the proposed function, the mathematical models of the DC motor, motor friction, worm drive, ball screw and load are established in MATLAB/Simulink. The differences between the simulation and the experiment under step, triangular wave, square wave and sinusoidal input signals are discussed. The parameter characteristics of clamping force-motor current and clamping force-ball screw displacement are obtained, which also verifies that the established model is correct. The results demonstrate that the automatic wear adjustment function of the new EMB could guarantee that the brake stroke and response time remain consistent across each braking manoeuvre.

KEY WORDS : Brake-by-wire, Electromechanical brake, Parameter characteristics, Automatic wear adjustment, Experimental verification

1. INTRODUCTION

The brake system, as an important part of the automobile, affects automotive safety directly. In the last ten years, Brake-by-wire (BBW) technology, originally applied to aircrafts' Fly-by-wire (FBW) systems, has been extensively studied worldwide (Haggag and Abidou, 2013; Miller *et al*., 2013; Jeon *et al*., 2014; Lee, 2014; Lee and Manzie, 2016), along with the rapid development of electric vehicles (EVs) and electronic technology. The global automotive BBW systems market is expected to grow to 12 million units by 2021, at a compound annual growth rate of 44 %. BBW technology is the direction in which automotive braking technology is developing. There are two branches of BBW, the electromechanical brake (EMB) and the electrohydraulic brake (EHB). Compared to the conventional hydraulic disc brake, the EMB has many advantages: (1) no brake fluid is required, making it environmentally friendly; (2) faster response; (3) more accurate control of braking force; (4) it is easier to integrate with ABS, TCS, ESP, and other control techniques (Dinggen, 2012; Jo *et al*., 2012; Yu and Zhao, 2013; Itani *et al*., 2016).

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BBW, as a new brake concept, can greatly improve the safety performance of vehicle braking, in line with future developments in EVs. Many scholars (Lee *et al*., 2012; Lostado *et al*., 2016; Villanueva *et al*., 2016) have carried out research in this area. Atia *et al*. (2016) investigated the sliding mode control strategy in a proposed BBW system and tested the compensation of wear in the brake pads and the system's tracking of braking commands. Huang *et al*. (2016) proposed a hierarchical transient fault tolerant scheme with embedded intelligence and resilient coordination for a BBW system to solve the problem associated with transient fault propagation and evolution in the brake control system hierarchy. The electronic wedge brake (EWB) is one of the BBW systems that has a self-energizing effect. Han *et al*. (2012) proposed an EWB, modeled it using dynamic equations, and designed a sliding mode controller based on the model. The clamping force was estimated and the contact point detection algorithm was also provided. The performance of the proposed controller was verified in simulations and experiments using a prototype EWB. Some of the world's leading automotive component manufacturers, such as Bosch, Toyota, Ford, Continental, Brembo, and others, have been carrying out research into BBW technology (Jong, 2015). The latest BBW patent of Robert Bosch (Helmut *et al*.,