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Autonomous Brakes Systems with Level 2 ADAS

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Abstract

Background: Autonomous Brake-by-Wire (BBW) systems are becoming a key component of automotive chassis development as vehicle electrification and intelligence gain traction.

Objective: The structure, operation, benefits, drawbacks, and potential future developments of BBW systems—such as electro-hydraulic braking (EHB), electro-mechanical braking (EMB), and the innovative multiple-pump EHB system—are examined in this paper.

Methods: With an emphasis on current advancements and real-world uses of BBW technology, literature and research articles spanning 2000–2024 were examined.

Results/Key Findings: BBW systems offer improved response, ADAS integration, and electric vehicle compatibility by substituting electronic control systems for conventional mechanical and hydraulic linkages. There are still issues with system redundancy and dependability.

Conclusions: Autonomous Brake-by-Wire is essential to contemporary vehicle technology, but its broad use requires improvements in safety and dependability.

Keywords: Brake-by-Wire, Electrohydraulic Braking, Electromechanical Braking, Autonomous Vehicles, Intelligent Chassis, Energy Recovery

Introduction and Background

Autonomous Brake-by-Wire (BBW) technology is a transformative innovation replacing mechanical linkages with electronic control. The technology aligns with the "new four modernizations" of electrification, intelligence, networking, and sharing in the automotive sector. Traditional systems dependent on vacuum boosters are being replaced to better suit electric vehicles. BBW meets the demands for precise control, efficient energy recovery, and modular vehicle architectures.

Review

Methodology

Research papers, technical documents, and case studies from reputable databases including IEEE Xplore, IOP Publishing, and SpringerLink were reviewed. Emphasis was placed on developments post-2015.

Historical Overview

The need to move beyond vacuum-boosted hydraulic systems, especially for EVs, led to early adoption of

EHB systems and further evolution into EMB systems.

Current Understanding

1. Electrohydraulic Braking (EHB) Systems

EHB replaces the vacuum booster with motor-driven or accumulator-driven systems while retaining hydraulic braking circuits.

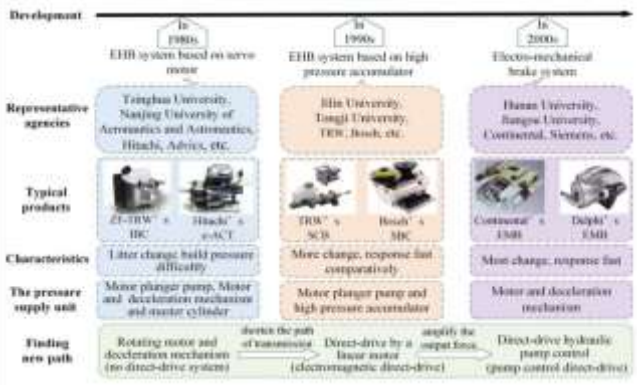

Figure 1: Structure and Characteristics of Brake-by-Wire System

2. BOSCH Tandem Master Cylinder EHB System

The BOSCH TMC8 provides modular, lightweight braking solutions for EHB applications.

Figure 2: BOSCH Tandem Master Cylinder EHB system

3. Motor Direct Drive Pressure Building EHB System

Advanced systems like BOSCH I-Booster combine ESC and direct pressure build systems.

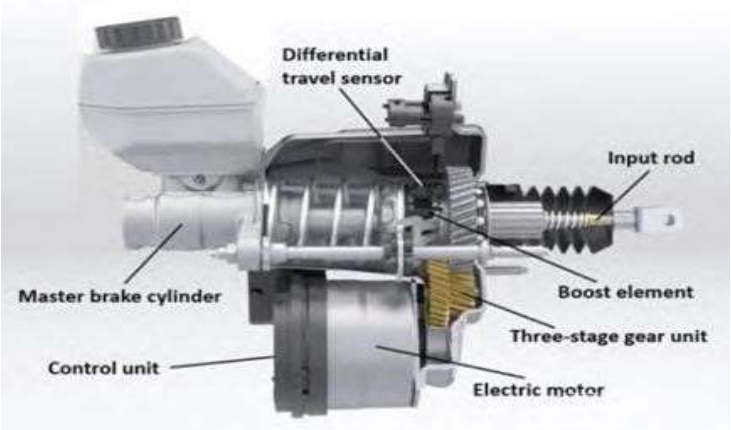

Figure 3: I-booster Structure

4. Electromechanical Braking (EMB) Systems

EMB replaces hydraulic lines with fully electronic motor-driven actuators, improving control, system diagnostics, and modularity.

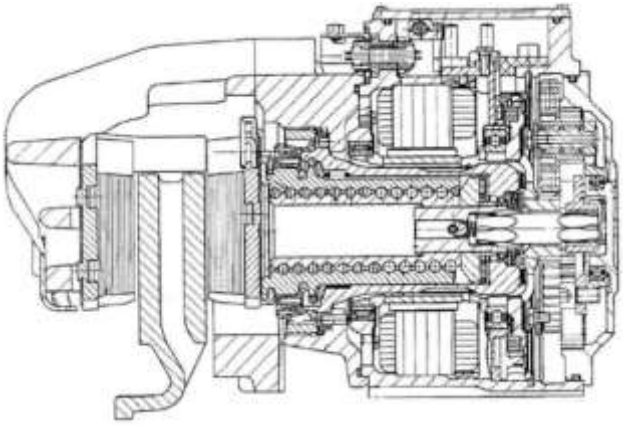

Figure 4: Continental Teves EMB Structure diagram

5. Multiple Pump EHB System

The multiple pump EHB system provides fast pressure building with six plunger pumps for EVs.

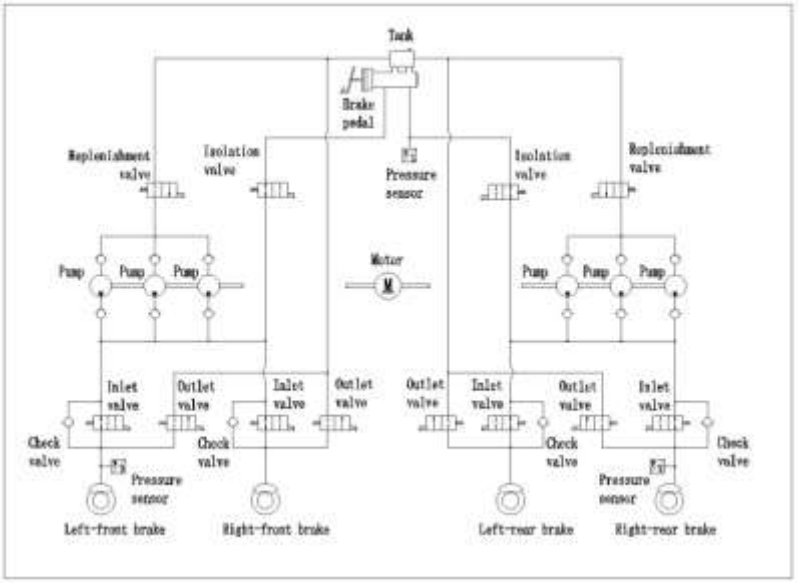

Figure 5: Multiple Pump EHB System

Key Studies

Key studies include BOSCH I-Booster, Continental MK C1, and EMB systems by Continental Teves.

Controversies or Unresolved Issues

Reliability, fail-operational designs, and user acceptance (pedal feel) remain areas requiring further research.

Practical Applications

BBW systems are critical in EVs, hybrids, and autonomous vehicles, enhancing energy recovery, torque vectoring, and dynamic stability control.

Discussion

BBW systems have revolutionized vehicle braking by offering modular, electronic alternatives to traditional methods. Key benefits include enhanced dynamic control, integration with ADAS, weight savings, and energy efficiency improvements. However, ensuring system safety, redundancy, and cybersecurity remains critical.

Conclusions

Brake-by-Wire technology is set to become a cornerstone of future automotive design, particularly for EVs and autonomous vehicles. Continued advancements in fail-operational architecture, cost reduction, and consumer trust-building will determine the pace of Autonomous BBW adoption.

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