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Sensotronic brake control and brake wear sensor

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ABSTRACT

Sensotronic Braking Control is an innovative Braking technology introduced by Mercedes. It is an electrically controlled braking system which is more precise than the conventional hydraulic system. SBC reduces the stopping distance by identifying the situation in hand. When the driver presses the brake paddle the calculations are made by sensors and signals are fed to a microcomputer which makes the further calculation is generated optimum braking pressure on each wheel. Due to high-pressure reservoir & electronically controllable valves, maximum brake pressure is generated sooner. SBC offers more safety in case of corner braking or on the slippery surface than conventional Hydraulic Braking. Moreover, this technology reduces the workload on the driver in traffic. The SOFT-STOP feature allows soft and smooth stopping in city traffic. In case if SBC fails due to malfunction then a backup hydraulic braking is provided for additional safety. But for effective braking system conditions of the brake pad and brake lining is to be ensured. Hence a microsensor is incorporated into a brake pad on a special test rig. This sensor calculates the thickness of the brake lining, its hardness and critical wear region of the brake pad. This system very effective in alerting the driver when wear of brake pads reaches the maximum limit and hence avoids further damage to the vehicle.

Keywords— *Proportional braking, SOFT-STOP, Traffic-assist, Critical wear region of brake pad*

1. INTRODUCTION

1.1 Sensotronic Brake Control

Today, when drivers press the brake pedal, the action of their foot moves a piston which is connected to a brake booster and a master brake cylinder. According to the force applied on the pedal, the master cylinder develops the appropriate amount of pressure in brake lines. The tested interaction of mechanics and hydraulics results in pressing the brake pads against the brake discs via the wheel cylinders.

On the similar note, in the Sensotronic Brake Control System of Mercedes-Benz, a variety of mechanical components are replaced by electronic components. The Brake booster will not be required in the mere future. Instead, a sensor gauge measures the pressure which is developed inside the master brake cylinder and it also measures the speed with which the brake pedal is pressed. This complete data is collectively passed to the SBC microcomputer in the form of electric impulse. A special type of stimulator has been developed by the Engineers which is connected to the tandem master cylinder. This moves the pedal utilizing spring force and hydraulics. This provides a similar brake feel to the driver. In simple words: while braking, there is a complete disconnection of the actuation unit from the entire system. It serves the sole purpose of recording the given brake command. In case of a major fault or power failure, SBC automatically utilizes the service of the tandem master cylinder and it establishes a direct hydraulic link between the brake pedal and front wheel brakes. This decelerates the car safely in a fraction of seconds.

The central control unit which is located beneath the bonnet is the prime component of the electrohydraulic brake. Here, the interaction of electronics and mechanics provides great benefit. Software, sensors, valves the microcomputer and the electric pump all of them work together and this facilitates highly dynamic brake management.

Along with the data relating to the actuation of the brake pedal, the SBC computer receives the signal from the sensor of which are connected to another electric assistance system. For example, the information regarding the wheel speed is provided by Antilock Braking System (ABS) while the Electronic Stability Program (ESP) makes the data available from turning rate, steering angle and a transverse acceleration sensor. Data highway is used by the transmission control unit to communicate the current driving range. Because of highly complex calculations, rapid brake commands are triggered which ensures the optimum braking force separately for each wheel. This makes the system more satisfactory.

2. CONSTRUCTION OF SBC

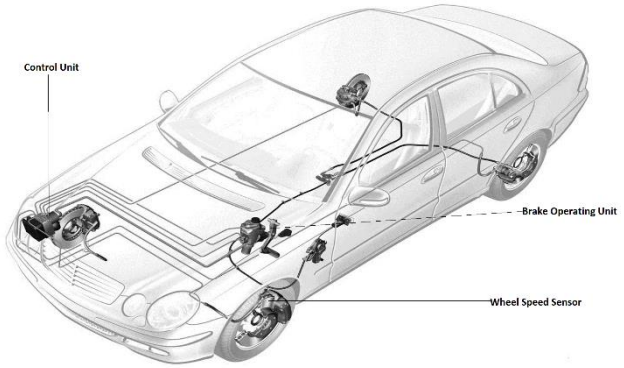

Fig. 1: Construction of SBC System

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3. WORKING OF SBC

The following flowchart describes the way in which various electronic and mechanical components interact and gives out the brake force required for the optimum braking.

SBC consists of:

1. Brake Operating Unit
2. Control Unit
3. Wheel Speed Sensor

3.1 Brake Operating Unit: This unit consists of a braking unit accompanied by a pressure sensor. When the driver presses the brake pedal the pressure in the master cylinder is recorded by the pressure sensor and also keeps the record of the brake pedal travel. The recorded data is sent to the SBC microcomputer located in Hydraulic Traction Unit.

3.2 Control Unit: The Central control unit is beneath the bonnet and is the master component of the electrohydraulic braking system. In the central control unit interaction of mechanics and electronics takes place providing highly dynamic management of brakes.

Brake fluid is stored in a high-pressure reservoir. This fluid enters the system at a pressure of 140 -160 bar. Here comes the SBC Computer into action. It regulates the pressure as well as the electric motor pump connected to this reservoir. As a result, a shorter response time than the conventional braking system. The hydraulic unit consists of four-wheel pressure modulators. These modulators meter out the required brake pressure and pass it to the brakes. In this way, the microcomputer's stipulation is a meet and each wheel is separately slowed down with respect to the driving stability and optimum deceleration. All these processes are monitored

3.3 Wheel Speed sensor: It is a three-wire sensor. The speed of each wheel is recorded individually and is sent to ESP.SBC and ESP, these both units are interrelated and therefore by the pressure sensors inside the wheel pressure modulators they decide the required brake pressure to be applied on each wheel

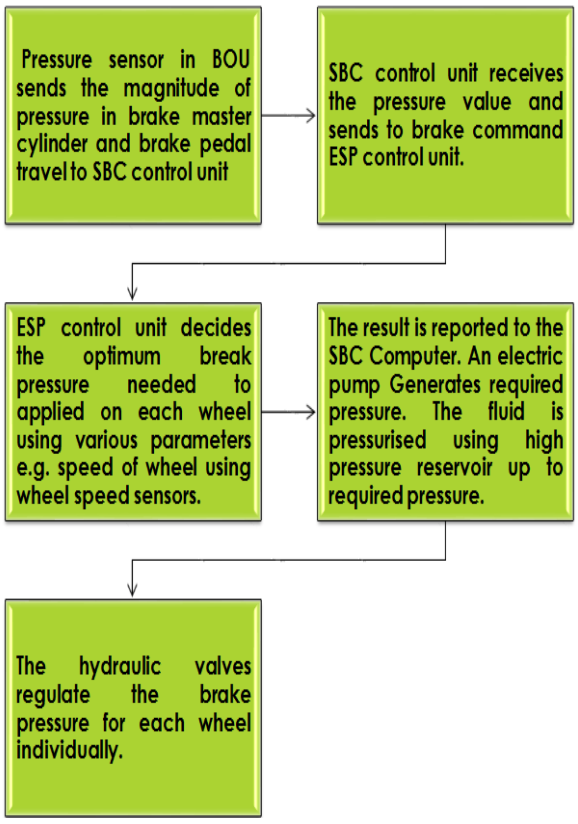

Fig. 2: Working of SBC System

4. FEATURES OF SBC

The Prime characteristic of SBC is the high dynamics while the pressure builds up and accurate monitoring of the behavior of the vehicle and the driver using refined sensors. For example, consider a case of emergency braking. The SBC will capture the quick movement of driver's leg from the accelerator to brake pedal as a sign of emergency stopping and responds automatically with the help of high-pressure reservoirs. The pressure is increased inside the brake lines by the system which results in instant pressing of the brake pads on the brake discs so that, brake pads can get a tight grip as soon as the driver steps on the brake pedal. As a result, the brake system is prefilled which reduces the stopping distance by 3% as that of the conventional braking system.

Driving Stability: SBC not only aids the emergency braking, it also stands as an important player in critical situations like the risk of swerving. In such condition, the brake system interacts with ESP which is called as Electronic Stability Program. ESP generates precise braking impulses at wheels or reduces the speed of the engine which ensures the vehicle is kept on the course.

Braking at Corner: As compared to a conventional braking system, SBC offers more safety when braking at the corners. SBC provides targeted and variable brake force distribution which is advantageous in influencing the car's compliance steer. In case of the conventional brake system, it meters out the brake pressure equally to the inner and outer wheels. SBC provides help in assigning the brake forces according to the situation. Therefore, the brake pressure is increased by the system at the outer wheels because more the vertical force, allows greater transfer of brake force. Simultaneously, the brake forces at the inner wheels are reduced. This provides higher cornering forces which are required to keep the vehicle on course.

4.1 Add- ONs of SBC

1. SOFT-STOP: This function of SBC software ensures smooth and gentle stopping of the vehicle. This provides comfort benefits to the driver and passengers when driving around the town.

2. Dry Braking: In case of rains, when the road surface is wet, SBC computer generates short brake impulses at regular intervals which ensures that the water film on the brake disc is dried off and SBC can operate with optimum effectiveness. The brake impulses are ultra-precise. Hence, the driver doesn't even recognize them. Dry braking function is activated when the wipers on the windscreen operate continuously.

3. Traffic Assist: SBC also consists of one of the so-called Traffic Assist function. This particularly helps while driving in the town. At a traffic signal, the driver needs to constantly shift between brake and acceleration pedal. Due to Traffic Assist, the driver only needs to operate the accelerator pedal. As soon as the driver removes his foot from the accelerator pedal, SBC slows down the vehicle at a steady rate of deceleration until it standstill. This function is operational up to 60 Km/h or 37 MPH and it is automatically cut-off at higher speeds.

Table 1: Comparison between Convectional Braking and SBC

Conventional braking system	SBC braking System
Approximate Emergency Braking	Perfect Emergency Braking
Greater stopping distance	Less stopping distance
Poor driving stability	Good driving stability
Skidding off the car on wet surface	No skidding on Wet surface
Non-uniform deceleration	Uniform deceleration
Less driver safety	High driver safety

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5. BRAKE PAD WEAR SENSOR

5.1 Introduction

Braking for every vehicle braking system is the most important safety feature what counts is how capable the system is to bring the vehicle to a safe controlled speed and preventing an accident or any personal injury. The braking system comprises of various components such as a master cylinder, a hydraulic control system, wheel cylinders and friction pads on each wheel.

As compared to the pad of leading end and the pad of trailing end is hotter. Hence, this region wears out more rapidly resulting in excessive taper wear which in turn results in excessive flex and pressing the brake pedal lower.

A research was carried out which used a microsensor to detect the wear limit of the lining of brake pads.

A luxury car named Proton Perdana V6 was made by Malaysia consisted of a brake pad lining wear limit alert system.

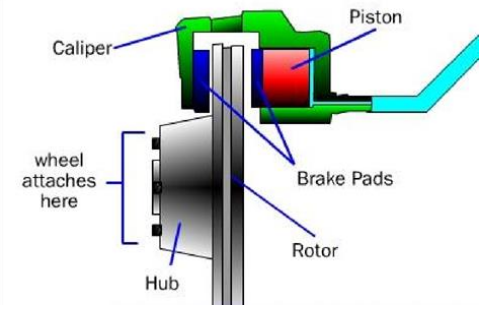

Fig. 3: Mounting of brake caliper on the rotor

The users of Proton Perdana V6 were alerted about the wear limit of brake pads by a mechanical touch sensing technique which produced mechanical noise so that the user can be alerted about the wear limit. But there were two disadvantages of this system. First, this system was only functional when the car is in continuous motion and the second disadvantage of this system was the alerting noise hardly reached driver's ears.
This lead to the invention of Brake pad wear sensor.

5.2 Operation of brake wear sensor

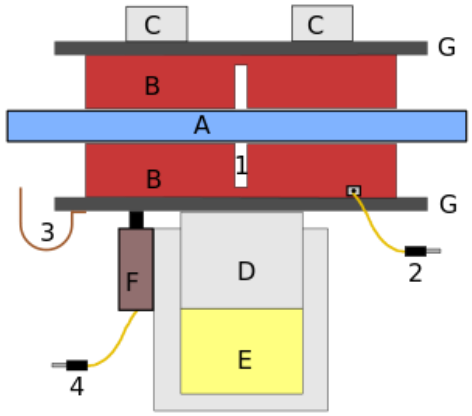

Fig. 4: Working of brake pad wear sensor

Pads **B is** shown in the figure are installed on the carriers **G**. The Piston pads **D** presses the brake pads against Rotor **A**. The Brake fluid **E** pushes the piston **D**. As a result, wear is induced on the pads. A similar wear is experienced by rotor A. But this wear is lesser than the brake pads. The modules **C** shown in the diagram are linked to the cylinder. This cylinder houses the piston **D**. The brake pads are replaced if any of the following cases are true:

1. Gap **1** shown in the figure vanishes or it will vanish soon.
2. The sensor which is fitted in the brake pad **2** contacts the rotor and makes a connection to the ground of the sensor.
3. The metal plate **3** contacts the rotor and starts creating a noise.
4. The distance between the Cylinder for Piston **D** and carrier **G** increases. As a result, the sensor **F** will send a signal outside the permitted range via the wire **4** of the sensor or ground the wire of the sensor if **F** is a contact.

6. CONCLUSION

In simple words, Sensotronic Brake Control is a braking system developed by an interdisciplinary approach. Mechanical components along with electronic components build an SBC system. The sensors, software, electric pumps, SBC microcomputer together allows a highly dynamic brake system. The fact cannot be neglected that the additional advantages of Sensotronic braking system provide uncompromising quality, stability, and longevity. Although if there is a small malfunction in the electronic part of the SBC system, no repair is available and the part has to be replaced completely. Hence the system maintenance costs a lot. Mercedes Benz engineers have taken a big step towards the safety of driver as well as the comfort of the driver by making such innovations. Brake Pad Wear Sensor is a simple and cheap solution of detecting the lining wear safety limit by alerting user is expected to help many brake pad manufacturers to embed the sensor to the most sensitive position of the pad based on the proposed methodology to provide safety and cost effective motoring.

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