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Antilock-Braking Systems (ABS) and Its Control

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Abstract: There is an increase in road accidents every day. People's lives are becoming risky when traveling on the highways. This research paper focuses primarily on development such a mechanical system that can automatically operate the vehicle and save human lives. A lot of different control methods have been developed for ABS systems. The components of model include quarter car model, tire model, brake actuator and PI controller. Under the changing road conditions, these approaches vary in their theoretical basis and efficiency. ABS attempts to control the wheel slip in order to achieve maximum friction and maximize steering stability also known as lateral stability. It is possible to stop the vehicle in the shortest distance while maintaining control of direction and to regulate or control the wheel speed. The key problems and the latest developments in their control techniques are summarized. For modern vehicles, antilock braking system (ABS) is used to avoid slip and lock the wheel after the brakes are applied. It is an automotive safety system, the controller is given to control the torque needed to maintain the optimal slip ration.

Keywords: ABS, Fuzzy Control, Intelligent Control, PI controller, Safety, Slip.

INTRODUCTION

Currently used in modern vehicles is the antilock-braking system (ABS). This enables safe driving AND capable of preventing accidents. Since 1950, many ABS control schemes have been developed. ABS is recognized as an important contribution to road safety because of its designed to keep a vehicle steerable and stable during heavy moments of braking by preventing wheel locking. It is well known extreme braking or when braking on a slippery road surface (wet, snowy, etc.) wheels will slip and lock[1]. ABS attempts to control the wheel slip in order to achieve maximum friction and maximize steering stability also known as lateral stability. It is possible to stop the vehicle in the shortest distance while maintaining control of direction and to regulate or control the wheel speed. ABS technology is also used in traction control system (TCS) and dynamic stability control of vehicles[2]. Some of the latest ABS systems have an accelerometer to evaluate the vehicle's deceleration. The anti-lock braking system consists of an electronic control unit (ECU) which is also called brain of antilock braking system, a wheel speed sensor, and a hydraulic modulator. ABS is a closed circuit, thus the feedback control system that modulates the brake pressure in response to the deceleration of the wheel and the angular velocity of the wheel to prevent locking. Chattering is the drawback of ABS. In place of the sign rule, the PI controller was used with the surface switching method to eliminate chattering[3].

ABS elements include: physical brakes of the vehicle, wheel speed sensors, electronic control unit (ECU), brake master cylinder, pump and valve hydraulic modulator as shown in Figure 1.

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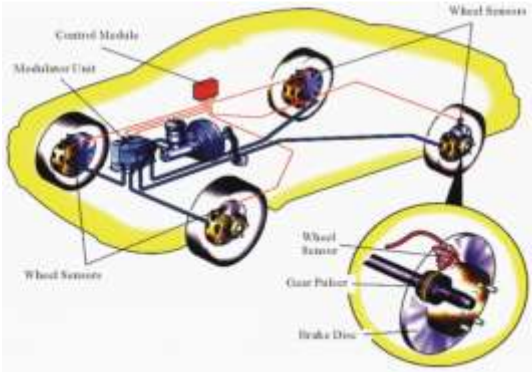

Figure 1: ABS Components

PRINCIPLES OF ANTILOCK-BRAKE SYSTEM

The explanation for anti-lock brake development is essentially very simple. Under braking, if one or more wheels lock then skidding is started and have a number of consequences like steering control are lost, tire wear will be abnormal and braking distance increases[4]. Braking produces a force that prevents the acceleration of a vehicle by applying a force in the opposite direction. A point is obtained where the tangential velocity of the tire surface and the velocity of the road surface are not the same in order to obtain an optimum slip corresponding to the highest friction[5]. The ABS controller will tackle the brake dynamics and the dynamics of the wheel. Wheel slip, S is defined as:

$$s = \frac{V - \omega R}{V}$$

R, V and ω denote the wheel rolling radius, and vehicle forward velocity, and wheel angular velocity.

Figure 2: Shows the anti-lock brake system. It shows the basic functionality of the different components in ABS systems and the data/information flow as well.

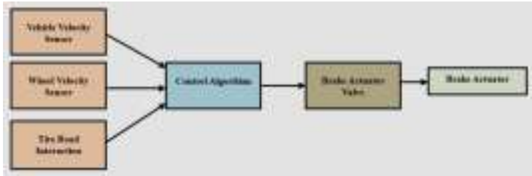

Figure 2: Block Representation of an ABS

ABS CONTROL

Anti-lock brake system presents the designer with unique challenges such as depending on road conditions, maximum braking torque, optimal performance controller must operate at unstable equilibrium point, brake pad coefficient of friction changes, tire slippage measurement signal, tire slip ratio due to tire bouncing, and braking system contains transportation delays[6]. The ABS consists of a traditional hydraulic brake system plus anti-lock components that influence the ABS control features. Due to the complex relationship between friction and slip, ABS control is a highly nonlinear control problem. Soft computing is one of the technologies used in the various aspects of ABS control. Below is a brief review of soft computing ideas and how they are used in ABS control. Fig.3 Shows the sampling of ABS control.

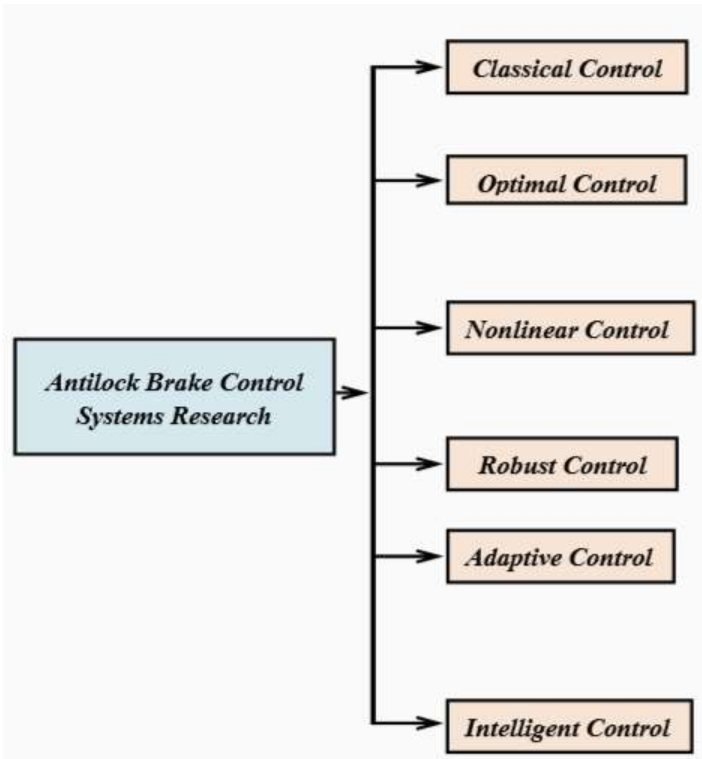

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Figure 3: Sampling of ABS Control

The well-known PID is used to improve the performance of the ABS out of all above control. PID controller is simple in design, but its performance is clearly limited. It does not have sufficient robustness to implement in practice[7].

IMPORTANTCE OF ABS

1. *Stopping Distance:*

When it comes to braking, stopping distance is an important factor. Stopping distance is the function of vehicle mass, initial velocity and the braking force. Stopping distance can be minimizing by increasing braking force and keeping all other factors constant. An antilock system can attain maximum frictional force and minimum stopping distance[8]. Fig.4 shows the effect of ABS.

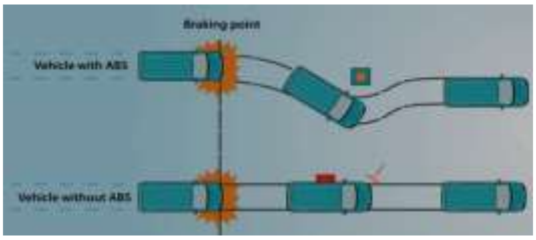

Figure 4: Effect of ABS

2. *Stability:*

The basic purpose of the braking system is to decelerate and stop the vehicle, maximum friction force may not be defined as asphalt and ice (p-split) surface, so that the braking force on one side of the vehicle is significantly higher than other[9]. Concept of antilock system that maintain slip both wheels at the same level and minimize friction coefficient then lateral force is not maximized. Brake is applying on both sides of wheel resulting in yaw or skidding moment that tends to pull the vehicle to high friction side and makes vehicle instable. Antilock system maintains slip both wheels at the same level and minimize friction of coefficient then lateral force is not maximized. Fig.5 shows the stability by using ABS.

Figure 5: Stability by Using ABS

CONCLUSION

Due to the complicated relationship between its components and parameters, ABS control is highly nonlinear control problem. ABS control systems tackle a wide range of problems and concerns. Anti-lock brakes help drivers to control a vehicle better under certain road conditions where hard braking may be required. System coordinates wheel activity with a sensor on each wheel that regulates brake pressure as needed to ensure that all wheels operate at a similar speed range. The system is used to prevent slip and locking of wheel when brakes is applied. It is automobile safety system in which controller is used to control necessary torque to maintain optimum slip ratio. Simulation and modelling is system that gives better comprehension for system works and also helpful in system development. It helps to obtain an ideal braking performance and safer driving. It plays vital role in road safety and designed to keep a vehicle steerable and stable during heavy braking moments by preventing wheel lock. It is well known that wheels is slip and lockup during severe braking or when braking on a slippery road surface.

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