A Review of Anti-lock Braking System

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Abstract

Many different control methods for ABS systems have been developed. These methods differ in their theoretical basis and performance under the changes of road conditions. The present review is a part of a research project entitled “Intelligent Anti-lock Brake System Design for Road-Surfaces of Saudi Arabia”. In the present paper we review the methods used in the design of ABS systems. We highlight the main difficulties and summarize the more recent developments in their control techniques. Intelligent control systems like fuzzy control can be used in ABS control to emulate the qualitative aspects of human knowledge with several advantages such as robustness, universal approximation theorem and rule-based algorithms. In present work first of all system dynamic equations are explained and a slip ratio is expressed in terms of system variables namely vehicle linear velocity and angular velocity of the wheel. By applying a bias braking force system, response is obtained using Simulink models. Using the linear control strategies like P-type, PD-type, PI-type, PID-type the effectiveness of maintaining desired slip ratio is tested. It is always observed that a steady state error of 10% occurring in all the control system models.

Keywords: ABS, Intelligent Control, Types, Future Scope.

INTRODUCTION

Anti-lock braking system (ABS) prevent brakes from locking during braking. In normal braking situation the driver control the brakes, however during sever braking or on slippery roadways when driver the wheels to approach lockup, the antilock takes over here. The ABS modulates the brake line pressure independent of the pedal force to bring the wheel speed back to the slip level range that necessary to the optimal braking performance. The ABS does not allow full wheel lock under braking. In simple terms, during emergency of braking, the wheel does not get locked even if you push a full auto brake pedal and hence the skidding does not takes place. It allowed driver to control the car easier, even on roads with low adhesion, such a rain, snow and muddy road. The brain of antilock braking system consist Electronic Control Unit (ECU), wheel speed sensor and hydraulic modulator. ABS is a closed circuit, hence it used the feedback control system that modulates the brake pressure in response to the wheel deceleration and wheel angular velocity to prevent the controlled wheel from locking.

Principles of Anti-lock-Brake System

The reason for the development of anti-lock brakes is in essence very simple. Under braking, if one or more of a vehicle’s wheels lock (begins to skid) then this will be abnormal. The obvious consequence is that an accident is far more likely to occur. The application of brakes generates a force that impedes a vehicles motion by applying a force in the opposite direction. During severe braking scenarios, a point is obtained in which the tangential velocity of the tire surface and the velocity on road surface are not the same such that an optimal slip which corresponds to the maximum friction is obtained. The ABS controller must deal with the brake dynamics and the wheel dynamics as a whole plant [15]. The wheel slip, S is defined as:

\[ S = \frac{V}{\omega} - \frac{R}{V} \]

where \( \omega \), R, and V denote the wheel angular velocity, the wheel rolling radius, and the vehicle forward velocity, respectively. In normal driving conditions, \( V = \omega R \), therefore \( S = 0 \). In severe braking, it is common to have \( \omega = 0 \) while \( S = 1 \), which is called wheel lockup. Wheel lockup is undesirable since it prolongs the stopping distance and causes the loss of direction control.
SUBSYSTEM OF ANTILOCK BRAKING SYSTEM (ABS)

Wheel-Speed Sensors bottom.

Each of the ABS wheel speed sensors detects the speed of the corresponding wheel. The sensor consists of a permanent magnet, coil and tone wheel. The magnetic flux produced by the permanent magnet changes as each tooth of the tone wheel (which rotates together with the wheel) passes in front of the magnet's pole piece. The changing magnetic flux induces voltages at a frequency corresponding to the wheel speed.

Electronic Control Unit (ECU)

The work of ECU is to receive, amplifies and filter the sensor signals for calculating the speed rotation and acceleration of the vehicle. ECU also uses the speeds of two diagonally opposite wheels to calculate an estimate for the speed of the vehicle. The slip of each wheel is obtain by comparing the reference speed with the individual wheel. During wheel slip or wheel acceleration condition signal server to alert the ECU. The microcomputer alert by sending the trigger the pressure control valve of the solenoids of the pressure modulator to modulate the brake pressure in the individual wheel brake cylinders. The ECU reacts to a recognized defect or error by switching off the malfunctioning part of the system or shutting down the entire ABS.

ANTI-LOCK BRAKE TYPE

Different schemes of anti-lock braking system uses depending upon the types of brakes use. Depending upon the channel (valve) and number of speed sensors the antilock brake are classified.

Four Channel, Four Sensor ABS

It is a more preferable type, the speed sensor on all the four wheels and contain separate valve for all four wheels. By using this setup, the controller monitors each wheel individually to make sure it is achieving maximum braking force.

Three Channel, Three Sensor ABS

This type of system is can be found commonly in the pickup trucks with four wheel ABS, on each of the front wheels there is a valve and a speed sensor, and one valve and one sensor for both rear wheels. The speed sensor for rear wheels is located in the rear axle. To achieve the maximum braking force, this system provides individual control to the front wheels. The rear wheels, however, are controlled together; they are both have to start to lock up before the ABS will active on the rear. With the help of this system, it's possible that one if the rear wheels will lock during a stop, reducing brake effectiveness.

One Channel, One Sensor ABS

This Arrangement can be seen in a pickup trucks and heavy trucks with rear wheel ABS. It consist one valve, which operate both rear wheel, and one speed sensor located in the rear axle. This is quite similar as the rear end of a three channel system. The rear wheel are monitored together and they both have to lockup before ABS starts its action. In this system there is also probability that one of the rear wheels will lock, results reducing in brake effectiveness. This system is easy to identify, usually there will be one brake line going through a T-fitting to both rear wheels.

IMPORTANCE OF ANTILOCK BRAKING SYSTEMS

The objectives of antilock systems are threefold:
1. to reduce stopping distances,
2. to improve stability, and
3. to improve steerability during braking.

These are explained below

Stopping Distance

The distance to stop is a function of the mass of the vehicle, the initial velocity, and the braking force. By maximizing the braking force the stopping distance will be minimized if all other factors remain constant. However, on all types of surfaces, to a greater or lesser extent, there exists a peak in fiction coefficient. It follows that by keeping all of the wheels of a
vehicle near the peak, an antilock system can attain maximum fictional force and, therefore, minimum stopping distance. This objective of antilock systems however, is tempered by the need for vehicle stability and steerability.

**Stability**
Although decelerating and stopping vehicles constitutes a fundamental purpose of braking systems, maximum friction force may not be desirable in all cases, for example not if the vehicle is on a so-called p-split surface (asphalt and ice, for example), such that significantly more braking force is obtainable on one side of the vehicle than on the other side. Applying maximum braking force on both sides will result in a yaw moment that will tend to pull the vehicle to the high friction side and contribute to vehicle instability, and forces the operator to make excessive steering corrections to counteract the yaw moment.

**FUTURE SCOPE**
There is a strong possibility that the federal government will mandate the use of antilock brakes on certain vehicles in the near future. ABS has been in use for several years, and evidence mounts regarding its benefits—specifically its ability to improve vehicle stopping distances and to maintain vehicle directional control under extremely slick road conditions. These findings are not without controversy, however. Initial claims of the benefits of ABS were significantly overstated, and many drivers have found that ABS offers them little or no advantage in their particular situation. In this respect, the controversy is a little like the one that surrounded seat belts.

Additional systems have been developed that enhance the benefits of the basic ABS. One of these systems is automatic traction control, called ATC. ATC uses the same components as ABS, but works at the other end of the speed spectrum—getting a vehicle started under slippery conditions. In operation, it senses each wheel's speed to detect when one or more wheels “break loose” and start to spin. When that happens, it applies the brake on that wheel 12 to 15 times per second to let it slow down and regain traction. In demonstrations, vehicles have been held by blocks on an ice-covered grade. When the vehicles start and the blocks are pull away, the vehicle without ATC spins its wheels and slowly slides backwards down the grade, while the ATC-equipped vehicle pulls its way up the ice.

It is expected that ABS, along with other new vehicle products, will continue to increase in popularity as the price goes down and the benefits become more appear.

**CONCLUSIONS**
The anti locking brake system provides us with an effective means to ensure that our new generation automobiles become safer as they continue to get faster & stronger. They provide the common man an opportunity to have a go at the new age monstrous engines which can churn out loads & loads of horsepower just at a small movement of the toe. It is a promising new concept which is catching up fast with the automobile owners and manufacturers the world over. The anti locking brake system certainly promises greater speeds and greater driving pleasures at lower risk level. Statistics show that approximately 40 % of automobile accidents are due to skidding. These problems commonly occur on vehicle with conventional brake system which can be avoided by adding devices called ABS.

**REFERENCES**