Abstract

The principle of braking in road vehicles involves the conversion of kinetic energy into heat. This high energy conversion therefore demands an appropriate rate of heat dissipation if a reasonable temperature and performance stability are to be maintained. While the design, construction, and location features severely limit the heat dissipation function of the friction brake, electromagnetic brakes work in a relatively cool condition and avoid problems that friction brakes face by using a totally different working principle and installation location. By using the electromagnetic brake as supplementary retardation equipment, the friction brakes can be used less frequently and therefore practically never reach high temperatures. The brake linings thus have a longer life span, and the potential “brake fade” problem can be avoided. It is apparent that the electromagnetic brake is an essential complement to the safe braking of heavy vehicles.

In this thesis, a new mathematical model for electromagnetic brakes is proposed to describe their static characteristics (angular speed versus brake torque). The performance of the new mathematical model is better than the other three models available in the literature in a least-square sense. Compared with old models that treat reluctance as a constant, our model treats reluctance as a function of speed. In this way, the model represents more precisely the aggregate effect of all side effects such as degree of saturation of the iron in the magnet, demagnetizing effects, and air gap. The software program written in Matlab can be used to code different brake characteristics (both static and dynamic) and evaluate their performance in different road scenarios.
A controller is designed that achieves wheel-slip control for vehicle motion. The objective of this brake control system is to keep the wheel slip at an ideal value so that the tire can still generate lateral and steering forces as well as shorter stopping distances. In order to control the wheel slip, vehicle system dynamic equations are given in terms of wheel slip. The system shows the nonlinearities and uncertainties. Hence, a nonlinear control strategy based on sliding mode, which is a standard approach to tackle the parametric and modeling uncertainties of a nonlinear system, is chosen for slip control. Due to its robustness properties, the sliding mode controller can solve two major difficulties involved in the design of a braking control algorithm:

1) the vehicle system is highly nonlinear with time-varying parameters and uncertainties;
2) the performance of the system depends strongly on the knowledge of the tire/road surface condition.

A nominal vehicle system model is simulated in software and a sliding mode controller is designed to maintain the wheel slip at a given value. The brake control system has desired performance in the simulation.

It can be proven from this study that the electromagnetic brake is effective supplementary retardation equipment. The application and control of electromagnetic brakes might be integrated with the design of vehicles and their friction braking systems so that an ideal match of the complementary benefits of both systems might be obtained to increase safety to a maximum while reducing vehicle operating costs to a minimum.