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The modelling of breaking control of electric vehicle

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Abstract: In this paper the problem electric vehicle braking is presented with its model. For year many systems have been developed and introduced as the standard to conventional vehicle with any kind of ICE. Currently the electrical vehicle safety system follow it adding the function of energy recuperation, but electric motors give more various opportunities and function. The braking with energy recuperation makes the: hybrid or battery EV more ecological in urban use. But some problems appear during emergency braking in any kind of vehicle. In the paper the overview of most popular electric vehicle propelling systems is presented with their physical and mathematical models. Classical scenarios of emergency braking with various control algorithms for DC and AC motors is simulated and discussed. The thesis about the self-adjustment of braking force by DC or asynchronous electric motor shortage (dynamic braking) is set and verified. In the simulation the phenomena of: batteries recharging current limitation, tire slip and wheel blocking have been taken account and modelled.

Keywords: Emergency braking, electric vehicle propelling systems, complex electric vehicle model, EV emergency braking

1. Introduction

The vehicle braking is extremely important for safety of vehicle occupant and others on the road.
The ICE vehicle can break with motors movement resistance or brakes. Contemporary modern ICE vehicle control of braking process to avoid the wheel blocking with the board-computers. The standardized ABS systems are responsible for safety during braking by controlling the wheel rotation speed and releasing the braking force when one wheel is blocked. If all wheels are blocked system can no react. Blocked wheels are sliding on the road and aren't able to control the vehicle movement direction. Other problem is the value of propelling and braking force which depends on slip s defined as [1,2,3,4,5]:
The typical characteristic of friction coefficient μ(s) to the slip is presented in figure 1. [1, -6].

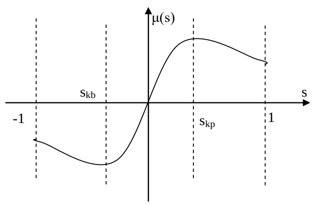

Fig. 1. The typical characteristic of friction coefficient to the slip

The most effective braking is when the slip is S_k. It is not easy to be reached for ICE driven vehicle. If we use the electric motors, we can control it braking with motor. In EV we can use various strategy of electric motor braking. In the paper the usage of dynamic braking as self-force adjustable system is discussed and modeled.

2. Results and Discussion

For simulation od dynamic process series of model has been developed. As the first approach the one wheel model (fig.2) was built with battery Control Device CD, Motor M and wheel to road interaction.

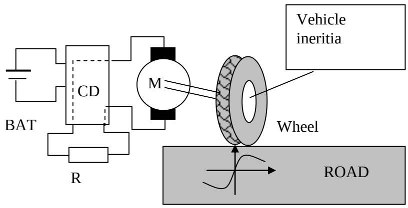

Fig. 2. The Electric vehicle driving system model with: BAT – battery, CD – transistor switch control device, R- resistor; M Permanent magnet DC motor

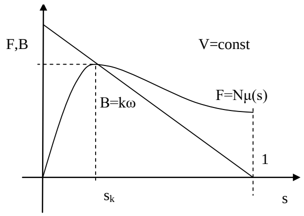

Fig. 3. The relation of motor dynamic braking and tire braking force slip characteristic

The concept of emergency dynamic braking base on assumption of self -optimization of braking force as the interaction of braking characteristics for tire and motor (fig.3)

For verification the full 3D model of electric vehicle was built in 4 versions [8,9,10]: One axle on motor drive; 2 axle two motor drive, one axle two motor (wheel with motor) drive. As the result of simulation for dynamic braking and dynamic braking controlled with transitory and energy recuperation with resistance control is presented in fig. 4

3. Concluding Remarks

Application of dynamic braking simplifies the control of maximum braking force seems to be promising of many advantages like less harmful for batteries energy recuperation, mitigation of brakes pads wears etc.

Such a solution is self-adjustable and fault tolerant in wider range than other braking strategies.

The combination of dynamic control with energy recuperation improves the battery recharging efficiency and safety.

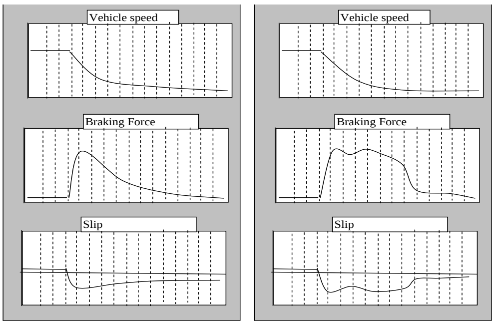

Fig. 4. Result of simulation. with constant shortage resistance a) with controlled shortage resistance and energy recuperation

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