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Research Article

Research on the Control Method of Electromechanical Composite Brake Based on Electric Wheel Drive Vehicle

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Abstract: Facing the increasingly serious environmental pollution and oil crisis, the development of automobile industry is facing a very serious challenge. For the sustainable development of automobile industry, the electric vehicle using motor as driving equipment can realize "pollution-free", which has become the focus of automobile research and development in many countries. In the research and development of electric vehicles, the electric vehicles driven by electric wheels have attracted the attention of all walks of life because of their ideal control characteristics and broad application prospects. In this paper, the electric wheel drive vehicle as the research object, the electromechanical composite brake control system is studied and analyzed.

Key words: Electric wheel drive vehicle; Electromechanical composite braking; Control method

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1 Introduction

The development of electric vehicles has become an inevitable trend for large automobile companies in various countries. Various plans related to energy vehicles have emerged one after another, which also shows the new requirements of national strategic development. Electric wheel vehicle is a kind of electric vehicle with special structure. Each driving wheel has its own driving system, which can simplify the transmission chain, reduce the difficulty of overall layout and improve the driving efficiency[1]. Since each driving wheel can be used as an independent power source to drive the vehicle, the wheel speed and torque can be controlled independently, to realize the functions of differential drive, differential braking and differential steering, and it is easy to implement various active safety controls to ensure the safety and controllability of the vehicle. Therefore, the driving and braking system of electric vehicles has become an important research direction of high-performance electric vehicles.

2 Working principle of mechanical and electrical hybrid braking system

The electro-mechanical hybrid braking control system used in this paper is composed of motor regenerative braking system and electromechanical braking system adopting series superposition braking method. In the braking process, the motor braking system is preferred. Because the variation rate and range of regenerative braking torque are limited by physical characteristics, only limited braking torque can be provided. In order to better balance the torque distribution between driving torque and braking torque, the electromechanical braking system can be activated only when the driving motor cannot provide enough regenerative braking torque. The braking system can maximize the stability of the system by making full use of the response characteristics of the drive motor and the high torque of the braking system.

Electro mechanical brake system (EMB) is a special type of brake controlled by wire. It replaces the traditional mechanical connection, and has the characteristics of reducing parts, reducing weight and improving performance. EMB can control each wheel completely independently, thus greatly improving the braking performance of the vehicle. The electromechanical brake system is mainly composed of electronic brake pedal, brake control unit and actuator. When the regenerative braking torque is insufficient, the EMB will be activated, and compared with the hydraulic braking system, the braking control unit will send the braking signal and transmit the electric signal to each actuator after the braking torque distribution is completed. The actuator drives the running motor and outputs it to the deceleration and torque increasing device, and then drives the piston to clamp the brake disc and combines with the motor brake to apply the braking torque to the wheel. It can detect the motion state and wheels of the vehicle in real time, and feed them back to the response controller for real-time judgment and adjustment, thus forming a closed-loop feedback control loop. EMB brake system with high performance actuator driving motor and fast electric signal transmission speed can provide more secure braking protection for electric vehicles.

3 Control method of electromechanical composite brake

The wheels of electric vehicles are equipped with various parts, and the normal operation of the whole vehicle requires complex control technology. Today the relevant control strategy is not mature. Compared with the coaxial drive wheel with differential, the driving torque of electric vehicle driven by electric wheel is independently distributed, and the driving torque is not automatically distributed. If one side drive system fails during driving, the general drive system on the other side will produce unique driving torque in the longitudinal direction. The additional yaw moment can cause steering interference, resulting in sudden vehicle instability. Theoretically, if a fault is detected on one side of the system, the other side can reduce the drive torque to zero[2]. In fact, there are many unstable factors that can cause the drive system to fail. For example, if the feedback signal is blocked, it will take tens of milliseconds or more to directly feed back to the vehicle, so the output torque of the normal drive system on the other side is much greater than that of the output torque of the fault drive system. The instability caused by single side drive system failure seriously threatens the safety of vehicle drivers and passengers.

In vehicle stability controller, center of mass yaw and sideslip angle are usually used as control variables. In the instability problem caused by the failure of one-way transmission system, the sideslip angle of the mass center is always very small and rapidly reduced to zero due to torque cut-off. The yaw speed can also be used as the only control variable to adjust the torque output of a normally operating motor. This method can suppress the yaw and sideslip behavior of the vehicle. However, the torque regulation range of the motor is limited, and the whole process is still changing. Therefore, the yaw angle can be used as another control variable to restore the vehicle to a straight line.

The active yaw moment can be obtained by distributing the braking torque to the wheels. Different drive motors can provide specific regenerative braking torque[3]. The rate and range of available regenerative braking torque are limited by physical characteristics. In order to effectively distribute torque and reduce energy consumption between the drive system and the braking system, the braking system is activated only when the available regenerative braking torque of the drive system is insufficient. By making full use of the responsiveness of the drive motor and the high torque of the braking system, the control system can maximize the stability of the vehicle.

4 Simulation and control effect analysis

4.1 Drive failure instability mechanism

In order to effectively study the stability control problem caused by the fault of one side drive system of electric vehicle, a vehicle fault simulation model for simulation test is established. The test condition is that the front wheel drive vehicle is straight on the road, and each front wheel is equipped with a hub motor. The road adhesion coefficient is 0.9, and the acceleration of the vehicle exceeds 90 km/h. After 3 seconds of acceleration, the left drive motor of the vehicle suddenly fails. At this time, the right drive motor is still in normal operation. Due to the instantaneous increased yaw moment, the vehicle becomes unstable. The vehicle parameters are shown in Table 1.

According to figure 1, the yaw angle and side slip angle of the center of mass increase suddenly after the machine fails, and the extra yaw torque generated will cause the vehicle to leave the normal track quickly. At this time, the lateral force generated by the tire balances with the center of the mass slip angle and the sharp increase of the yaw moment until the vehicle’s yaw is

Table 1. Vehicle parameters

Symbol	Parameter	Numerical value
m	Vehicle weight	1070 kg
R	Wheel radius	0.321m
I_z	Vehicle moment of inertia	1270 kg/m^2
f	Rolling resistance coefficient	0.015
A	Windward area	1.85 m^2
C	Air drag coefficient	0.35
I_i	Wheel transmission inertia	1.2 kg/m^2

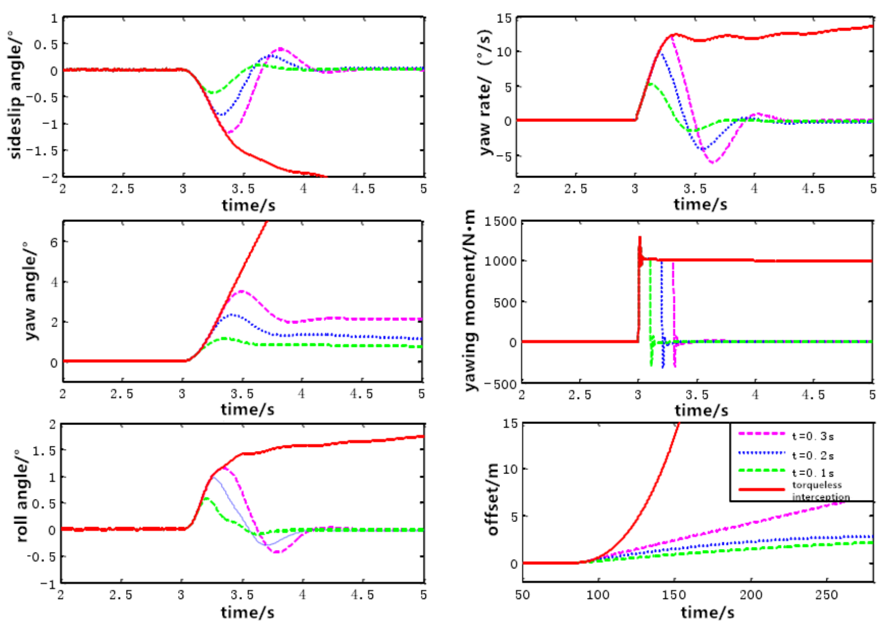

Figure 1. Change of vehicle state parameters under different torque interception delay time

zero. If emergency measures are not taken, the vehicle will lose full control, which is very dangerous. If the other side of the normal drive motor has a torque cut-off function, the instability of the vehicle may slow down.

After comparing different torque cut-off times, the following conclusions can be drawn: The longer the torque cut-off time, the greater the additional yaw moment of the vehicle. At the same time, the yaw velocity and sideslip angle of the center of mass are reduced. The slower the vehicle speed, the greater the lateral offset distance and yaw angle of the vehicle, and the more dangerous the vehicle condition is. In addition, after increasing, the yaw angle of the vehicle cannot be reduced, and it is impossible to maintain the original driving direction by deviating from the track of the vehicle, and the lateral offset distance increases, so the vehicle will not be out of danger.

4.2 Electromechanical composite braking control under vehicle failure

In order to further verify the accuracy of the electromechanical composite braking system, the electromechanical composite brake joint simulation test is carried out. The test condition of the simulation test is that the front wheel drive electric wheel drive vehicle accelerates linearly at the speed of 90km/h. The road adhesion coefficient is 0.9, and the motor output torque of two driving wheels is 400NM. When the

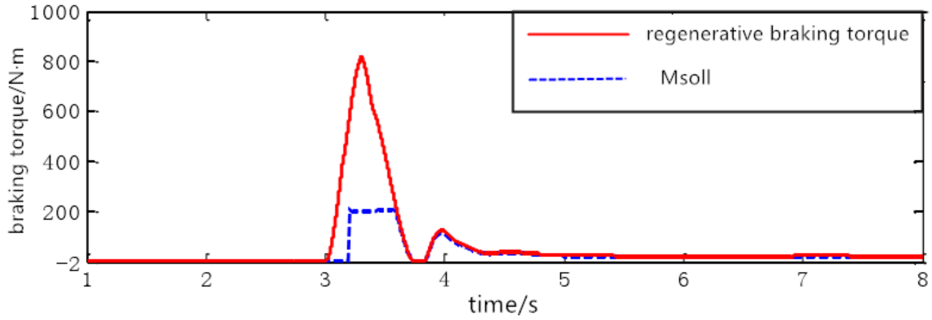

Figure 2. Braking torque of right wheel

vehicle accelerates to 3 seconds, the left drive system suddenly fails and the driving torque is lost. The right drive system performs torque interception and applies regenerative braking torque after a delay of 200 ms. The results are shown in Figure 1.

According to figure 2, when the wheels rotate at high speed, the regenerative braking system can only provide limited braking torque, and there is still a certain gap between the expected values required for the vehicle to reach a stable state. Because the braking torque provided by the regenerative braking system is insufficient, the yaw angle cannot be reduced to a safe range rapidly. Therefore, the regenerative braking torque is always on, and the braking torque value is not zero. The speed and side slip angle decrease speed of the fault vehicle is faster than that of the single regenerative braking system, because the electromechanical composite braking system can provide greater braking, torque can control the yaw angle of the vehicle smaller, greatly improving the driving safety of the vehicle after failure. Therefore, the vehicle can quickly return to a stable state, reducing the incidence of traffic accidents.

5 Conclusion

Comprehensive related theory and simulation test, we can conclude that the development of Automobile Electromechanical composite braking system is correct, it can help people to reduce the mistakes when driving the car to a certain extent, so as to reduce the incidence of traffic accidents. With the continuous progress of society, the electromechanical composite brake of electric wheel drive vehicle will also get continuous development.

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