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Analysis on Control Algorithm of Automobile Electronic Differential System

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Abstract

This paper establishes the wheel and vehicle dynamics model during the acceleration of the vehicle, and proposes an electronic differential system control algorithm based on the driving PID control. This control algorithm has good adaptability to the road surface; in addition, this paper establishes a simulation system of this control algorithm, the acceleration performance of the differential system on the road is analyzed and verified, and the results show that the proposed electronic differential system control algorithm significantly improves the vehicle's acceleration performance.

Keywords

Automobile; electronic differential system; simulation.

1. INTRODUCTION

Electronic Differential System (EDS) is a differential lock system whose locking coefficient is controlled by electronic device. When the conditions on the road where the car's driving wheels are located are very different, it can lead to severe track slip of the unilateral driving wheels and affect the vehicle's dynamic performance. The EDS system can control the locking degree of the two driving wheels through the locking device, and control the slip of the two driving wheels within a certain range, so as to give full play to the driving force, improve acceleration performance and driving stability. Since the electronic differential system significantly improves the driving performance of vehicles, ABS has become a common safety device for new cars. At present, research on EDS control algorithm is rare, most of the relevant research literatures explore the dynamics principle and performance of limited slip differential, the product development and research of limited slip differential and the simulation analysis of the vehicle's control stability of differential locking control are carried out. This paper establishes the wheel and vehicle dynamics model of the vehicle acceleration process, proposes an electronic differential system control algorithm based on the drive wheel slip rate error difference PID control, and establishes a simulation system for the vehicle acceleration process control based on the control algorithm. The acceleration performance of vehicles with and without electronic differential system and compulsory differential on roads is analyzed and verified, respectively. The results show that the proposed electronic differential system control algorithm significantly improves vehicle acceleration performance.

2. VEHICLE DYNAMICS MODEL

The coordinate system xoy is established with the vehicle center of mass as the origin. The x-axis is the longitudinal center line of the vehicle body, and the forward direction of the vehicle is the positive direction; the y-axis is the transverse coordinate axis of the vehicle body, and the

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positive direction points to the left. δ and δ 2 are the steering angles of inner front wheel and outer front wheel respectively, RAD; α I (I = 1, 2, 3, 4) i s the sideslip angle of tire, RAD; β is the sideslip angle of vehicle mass, RAD; VI (I = 1, 2, 3, 4) is the absolute speed of wheel center, M / S; FXI and FYI (I = 1, 2, 3, 4) are the longitudinal and lateral forces of tire, n.

The vehicle dynamics model is shown in Fig.1.

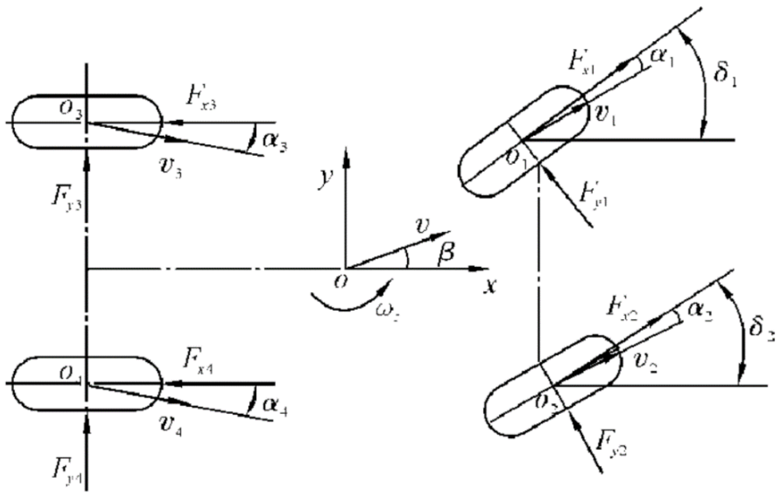

Fig 1. Vehicle dynamics model

The vehicle motion equation in the coordinate system xoy:

$$F_x = \mathrm{m}(\mathrm{x} -\cdot \mathrm{y}\omega_z)$$

$$\mathrm{F}_y = \mathrm{m}(\mathrm{y} -\cdot \mathrm{x}\omega_z)$$

$$\mathrm{M}_z = \mathrm{Iz}\omega._z$$

Fx and Fy are the resultant force of vehicle center of mass in the coordinate system xoy, N, MZ are the yaw moment, n·m; m is the total body mass, kg; X, y are the vehicle acceleration in the coordinate system, m/s; X and y are the vehicle speed in the coordinate system, m/s, ω is the vehicle yaw acceleration, rad/s; ωz is the vehicle yaw rate, rad/s; Iz is the vehicle inertia.

3. WHEEL MODEL

The force analysis of the driving wheel is shown in Fig.2.

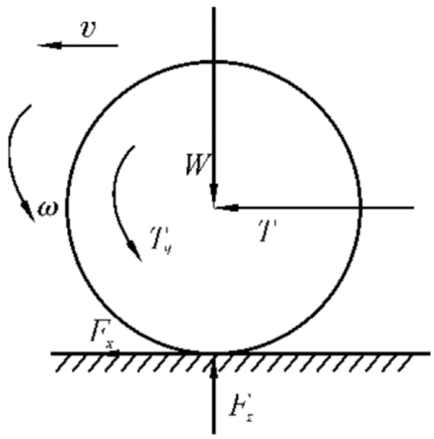

Fig 2. Force analysis of driving wheel

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The differential equation of motion is

$$Tq1 - Fx1\ rd = Iw\dot{\omega}1$$
$$Tq2 - Fx2\ rd = Iw\dot{\omega}2$$
$$Tq1 + Tq2 = T0$$
$$Tq2 - Tq1 = Tr$$

Iw is the wheel inertia of the wheel, kg.m2; ω1, ω2 is the angular acceleration of the two driving wheels, m/s2; Fx1, Fx2 are the ground driving forces of the two driving wheels, N; rd is the wheel rolling radius, m; Tq1, Tq2 are the driving torques of the two half shafts, N·m; Tr is the EDS system locking torque, N·m; T0 is the differential input torque.

4. PID CONTROL BASED ON DRIVE WHEEL ERROR DIFFERENCE

Existing EDS system often use the speed difference between the two driving wheels measured by the ABS system as the input parameter of the control system. The shortcoming of this control strategy is that it cannot make full use of the adhesion conditions on the road surfaces on both sides to maximize the ground drive. Force and maintain anti-skid ability. The difference between the actual slip ratios of the two driving wheels is used as the input parameter of the control system [7], and the controllability is good only on the road surface with uniform and uniform adhesion conditions. The ideal electronic differential system is to adjust the locking degree of the differential in a timely manner according to different road attachment conditions, especially on off-road surfaces, so that each drive wheel can achieve the best slip rate. Therefore, this paper proposes to use the difference between the slip ratio of the drive wheels as the control system input parameter, that is, to compare the difference between the optimal slip ratio of the two drive wheels and the actual slip ratio to adjust the locking degree of the differential. The optimal slip rate and actual slip rate of each wheel can be obtained through parameter identification of the ABS system.

Setting the best slip rate on the side with better road adhesion conditions be S10, and the actual slip rate be S1, then the difference between the optimal slip rate and the actual slip rate is ΔS1 = S10 -S1; The optimal slip rate of the wheel on the side of the difference is S20, and the actual slip rate is S2. The absolute value of the difference between the optimal slip rate and the actual slip rate is ΔS2 = S20 -S2. Taking the slip difference error of the drive wheels on both sides as ΔS = ΔS1-ΔS2 as the control system input parameter, and the EDS system lock-up torque Tr as the control parameter, the PID controller is used to form the EDS control system. The PID control algorithm is simple and practical, and has been widely used in vehicle control [8-9]. The difference between the slip rate error of the drive wheels on both sides is discussed in the following two cases: 1) ΔS> ε, ε is the control accuracy, that is, ΔS1-ΔS2> ε, indicating the slip rate and optimal slip of the drive wheels on one side The rotation rate deviation is large, no large ground driving force is obtained, and the driving wheel on the other side is more slippery. At this time, the EDS system lock-up torque Tr should be increased. 2) ΔS ≤ε, that is, ΔS1-ΔS2 ≤ ε, indicating that the difference between the slip rate of the drive wheels on both sides and the deviation of the optimal slip rate is within the control accuracy range. Therefore, the EDS system lock-up torque Tr remains unchanged. . The setting of the control accuracy ε mainly affects the adjustment frequency and stability of the EDS controller, which can be obtained through a real vehicle matching study. When the vehicle is turning, the value of the control accuracy ε also needs to be matched with the stability of the vehicle.

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5. CONTROLLER PERFORMANCE ANALYSIS

5.1 EDS Control System Model

The EDS control system model is shown in Figure 3. In the body dynamics module, the input signal F is the wheel force, the output signal Vx is the longitudinal speed of the vehicle's center of mass, the motion parameters are the longitudinal speed of the center of each wheel and the wheel side deflection angle, and Fz is each Wheel load, wheel 1, wheel 2 are two driving front wheel modules, wheel 3, wheel 4 are two non-driving rear wheel modules, of which Tq1 and Tq2 are driving torques of two driving wheels, ω1 and ω2 are two driving respectively Wheel speed, s1, s2 are the slip ratios of the two driving wheels, Fxi, Fyi (i = 1, 2, 3, 4) are the longitudinal and lateral forces of each wheel, Vxi, αfi (i = 1, 2 , 3, 4) are the center longitudinal speed and wheel side angle of each wheel respectively; in the engine and drive train modules, Tq is the driving wheel drive torque, Tr is the EDS system lock-up control torque, and ω0 is the speed of the differential case; In the PID controller module, the parameters are the same as above.

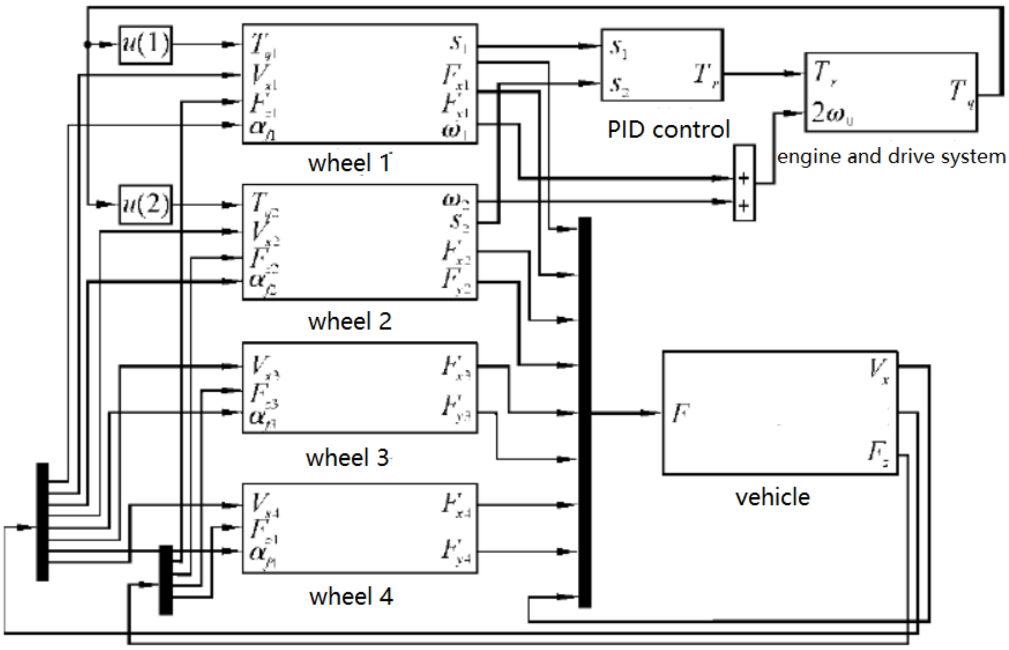

Fig 3. EDS control system model

In actual application, the actual slip rate and optimal slip rate of the two driving wheels of the input signal of the PID controller of the EDS system can be obtained by the ABS system parameter identification module.

6. CONCLUSION

By establishing a dynamic theoretical model of the vehicle acceleration process, and its simulation system and electronic differential control system, performance analysis and verification of the proposed electronic differential system control algorithm based on PID control are performed. Results shows that the proposed electronic differential system control algorithm based on the drive wheel slip ratio error PID control significantly improves the vehicle's acceleration performance and driving stability; the PID control algorithm is simple and

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practical, and it has further research and practical application value to the electronic differential control system.

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