Study on the Controlling Stability Coordination Control of Car Based on Electric Air Suspension

Min Yang[1,a,*], Xiao Zhang[2]

[1] College of Mechanical Engineering, Nanjing University of Science and Technology ZiJin College, WenlanRoad 89, Qixia District, Nanjing, Jiangsu Province, 210046, China

[2] Nanjing Xingqiao Y-tec Automobile Parts Co. Ltd. No.29 Jingyou Road, Jiangning Science Park Jiangning District, Nanjing, Jiangsu Province, 210058, China

[a] yangmin082@njust.edu.cn

*corresponding author

Keywords: Electrically Controlled Air Suspension, Car Stability, Coordinated Control.

Abstract: Suspension, as an important collusion of automobile structure, can improve the smoothness of automobile driving and the comfort of ride. By adjusting the characteristics of spring stiffness and damping, the stability of automobile in different operation can be improved effectively. The system control mode of electric control air suspension is discussed in this paper.

1. Introduction

With the rapid development of economy, people's demand for automobile is increasing day by day, but people's attention to automobile only lies in its economic practicability, power performance and comfort performance, neglecting the smoothness in the control, however, the smoothness is the primary content of the choice of automobile, only if the automobile has better smoothness, it can reduce the fatigue degree of the driver in the driving process and make it feel the comfortable degree of the control automobile.

2. General Description of Electrically Controlled Air Suspension

The electrically controlled air suspension is mainly composed of suspension mechanical parts, pneumatic, sensor, ECU and so on. and the air suspension component is composed of air spring, shock absorber and corresponding guide mechanism, using air spring instead of the original spiral spring. because of the load bearing, the device of the shock absorber is to limit the downward stroke and prevent the separation of the air spring from the base. Based on the air spring can only bear the vertical load content, therefore, when the real car is installed, it is necessary to install the corresponding guide mechanism to bear the longitudinal and lateral forces to complete the layout of the car body.[1]. The pneumatic and sensor contains the contents of air compressor, gas storage tank, solenoid valve, height sensor and pressure sensor, in which the function of air compressor is to provide compressible air for gas storage tank and air spring, and to realize the gas charge and discharge in the air bag, so that the pressure sensor can measure the pressure in the air storage tank and air spring airbag, so as to perfect the height sensor to measure the relative displacement work between the body and the car bridge, and then convert it into an electrical signal to the ECU. The function of ECU is to collect the sensor signal and analyze and dispose its signal content by using the pre-set control strategy.

It should be explained here that ECU is the core component of electronic control air suspension, which is formed by hardware and software, and the hardware system is the main control chip and corresponding peripheral circuit, which satisfies the function and design content of electronic control air suspension system. and the team building system is the core content of the ECU, mainly using the control strategy of the electrically controlled air suspension and the corresponding algorithm to complete the design content of different devices in the electrically controlled air

  DOI: 10.25236/cseem.2020.068

suspension.

3. Advantages of Electronic Air Suspension System

In the current configuration of the car, the electronic control air suspension system has become the basic content of the mechanical components. By introducing advanced electronic technology to control the air springs and shock absorbers, the stiffness of the springs and the damping coefficient of the shock absorbers are regulated. Therefore, the electronic control air suspension system has the following number:

The electrically controlled air suspension system can effectively lift the height of the body within a certain range, and improve the passability of the automobile substantially[2]. The electrically controlled air suspension system can improve the stiffness and damping coefficient of the air spring by controlling the solenoid valve, reduce the impact degree brought by the road surface to the maximum extent, reduce the vehicle shock, and complete the smoothness of the vehicle driving. At the same time, the electronic control air suspension can complete the correction and compensation of the forward tilt mechanism when turning through the electronic control unit, effectively restrain the adverse reaction of the body, improve the smoothness of the driving, reduce the resistance of the tire on the bumpy road surface and reduce the energy loss in the process of driving acceleration or sharp brake, etc. Synthesizing the above contents, it is not difficult to see that the electrically controlled air suspension has unparalleled advantages in the active suspension system, thus ensuring the smooth belt in the driving process of the automobile (see figure 1).

Figure 1 Electric air suspension

4. Analysis of Characteristics of Air Spring and Shock Absorber in Electric Air Suspension

Generally speaking, the air spring stiffness characteristic has the important relation with its influence factor, therefore, considering the car spring load quantity is to carry on the comparison with the vehicle quality, the car spring load quality has the small change compared with the vehicle quality, the spring load quality does not change. In charge and discharge, the equilibrium position of the air spring is small, and the working height is inconvenient. For any spring, it is necessary to consider the change of working area, effective volume and other parameters to complete the initial working height of the spring, and determine the stiffness characteristics of the air spring[3].

Different from the traditional suspension system, the electrically controlled air suspension class changes the stiffness of the air spring through the heavy gas process, thus changing the shock absorber and controlling the damping parameters. In the selection of relevant materials, two kinds of air springs can be used to test the gas pressure value in the initial capsule, and the stiffness test can be changed. For example, when the pressure value in the capsule is 0.3MPa, the stiffness of the spring is 11560N/m, the pressure value in the capsule is 0.4MPa, and the stiffness of the spring is 12412N/m, which is in accordance with the set range, so the two states of soft and hard are fully in accordance with the set content.

Therefore, in the car air spring stiffness control setting, the car spring load is set to a fixed value,

only the speed and road quality should be taken into account, if the road surface is more stable, define it as high speed driving, if the road surface is bumpy, define it as low speed driving, so as to study the vehicle stability (see figure 2).

Figure 2 Electronically controlled air suspension

45 km/h and 80 km/h can be used as thresholds, which are defined as low speed driving when the speed is less than 45 km/h, when the air spring deflates to the set soft state. And when the speed is greater than 80 km/h, it is defined as high speed driving, when the air spring deflates to a set hard state. This can complete the transition between the two speeds, from high-speed to vulgar, air-spring for the hard state. When the speed drops to 45km/h, the air spring deflates to a soft state[4].

5. Damping Control Strategy

With the influence of various factors, the stiffness of the target port of the air spring changes, and the damping to its matching will also change. Assuming that the spring load mass is constant, the algorithm of its genetic particle swarm is optimized, and it is also necessary to take the speed and pavement factors into consideration, to optimize the regions of different speeds, and to set the target damping value and speed curve, such as, in the high-speed zone, to consider the smoothness of the pavement, and the hard state is released. In the transition zone, it is necessary to consider the smoothness of the road surface, and the hard state gradually becomes excessive to the soft state. low speed zone, the road surface is bumpy road shape, the soft state is released. By comparison, the change and adjustment of damping coefficient can improve the smoothness of the car.

The suspension mass is used to optimize the rms of acceleration, and the constraint condition is compared with the root mean square of the tire dynamic load and the root of the suspension dynamic deflection.

6. Stability Control and Analysis

Through the simulation analysis of the automobile air suspension system, an integral white noise is used as a white noise model to simulate the air suspension system, considering the stiffness, damping, road surface and speed of the vehicle. If the structure of the vehicle, including the suspension system, is rigid, the stiffness of the body and frame is large enough, and the vibrations caused by the frame elasticity are not considered. Of course, the simplified ability of the electronic control air system should be considered, only the linear stiffness of the spring and the linear damping content of the shock absorber can be considered. ignore the damping value of the vertical deformation of the tire, simplify the vertical characteristics of the tire, test its progressive spring stiffness, complete the optimal design and active control design of the suspension system according to the content of the hypothesis, and the smoothness of the automobile is closely related to the chassis performance of the suspension system. When the car is moving in a uniform straight line at the horizontal plane, the uneven surface of the road causes the body to jump up and down, the left and right side and the front and back pitching motion, through which the driver and the passenger feel discomfort. The suspension system is the main link to isolate and attenuate the uneven vibration of different pavements. According to the size of the vibration output and the content of the

suspension stiffness and damping, when the car turns, the car will rotate the tilting axis under the action of the sound and lateral force to keep its body stable. If the tilting angle of the body is too large, the driver and passenger will feel the bumping and discomfort. If the vertical load changes in the turning process of the car, the tilting force will have an important vertical load change, which will affect the smoothness of the car operation. Therefore, the inclination angle of the car has a direct relationship with the vertical load change of the tire and the inclination stiffness of the suspension. Based on this, the change of the angle and the vertical load of the tire can be reduced completely by the change of the stiffness of the suspension line.

The electrically controlled air suspension has the function of controlling the smoothness of the automobile, adjusting the stiffness and damping of the suspension according to the uneven condition of the road surface and the information of the speed, so as to reduce the different conditions of the body due to the road surface, so as to improve the comfort of the vehicle. By using electronic control to control the different posture changes of the body with its suspension, the ECU can adjust the speed according to the turning angle of the car and judge the running state of the car, and effectively adjust the soft and hard state of the suspension stiffness when the car turns, thus improving the stability of the vehicle driving.

Based on the coordinated control of the stability of the car by the electronic control air suspension system, the controlled air suspension can be graded and adjusted in the form of shock absorber and air spring split to realize the control scheme of damping continuous regulation. The software scheme is used to improve the smoothness of automobile under different operation. control and validation of the electrically controlled air suspension hardware (see figure 3).

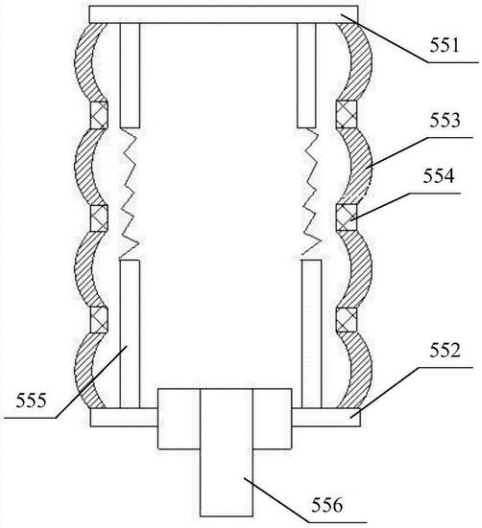

Figure 3 Electronically controlled air suspension

7. Conclusion

The control mode of air spring and shock absorber under different operation is designed by analyzing the structure of air spring and shock absorber. Based on the stiffness characteristics of the air spring and the continuous change of damping of the shock absorber, a detailed theoretical analysis is made. Combining with fluid mechanics, the structure principle of air spring is analyzed, and the relation between different spring and stiffness parameters is obtained. Based on the analysis of the contents of the vehicle driving, considering the driving conditions of the vehicle, the stationary test of the electrically controlled air suspension driving is completed. The above contents can effectively improve the characteristics of the suspension and improve the smoothness of the vehicle driving.

Acknowledgements

The work described in this paper was supported by the General Natural Science Foundation in

2016 of Jiangsu Educational Committee, PR China, “Research on driving stability and control of tilt steering three wheel ENV” (16KJD460004)

References

[1] Zhou, Yazhuo. Automotive electrically controlled hydraulic active suspension system analysis. Internal combustion engine and accessories, no. 23, pp. 34, 2019.

[2] Xie, Weidong., Chen, Peng. Dynamic simulation based on new electronic control suspension. Journal of Zhejiang University of Technology, vol. 47, no. 04, pp. 382, 2019.

[3] Wang, Hong., Qiu, Guansheng. Research on key technology of automotive electric control suspension system overhaul. Microcomputer applications, vol. 35, no. 06, pp. 153, 2019.

[4] Zeng, Liangming. Car ride comfort based on active suspension and coordinated control of handling stability. Hunan University, 2017