Research on Damping Mode of Passenger Vehicle Air Suspension System

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Abstract. With the continuous development of economy in China, the demand of both passenger car volume and its comfort increases. The air suspension system has solved the comfort problem as the times require. At the same time, the reliability of the product has attracted more and more attention from users. This study describes the structure and design principle of the air suspension system, and makes an analysis and Discussion on the key use effect, i. e. the damping effect.

1. Introduction
In recent years, China's economy has made rapid progress, passenger cars can be said to be almost everywhere in every family. As each family begins to own a passenger car, they begin to demand comfort. The air suspension system of passenger car emerges as the times require. The system can make passengers ride as smoothly as possible on bumpy road sections. The air suspension system of passenger car is an important component of the stability system of passenger car body. The performance of the air suspension system is directly related to the comfort of passengers. And this function also directly affects the evaluation of passenger cars in the market.

2. Basic function of air suspension system
The air suspension system consists of oil-free air compressor (A), solenoid valve (B), air reservoir (C), air bag (D), height sensor (E), ECU control box (F), relay (G), remote controller (H).
The principle of air suspension system is as follows:

Dry compressed air is transported from oil-free air compressor (A) to solenoid valve (B). The compressed air is stored in air reservoir (C) through solenoid valve (B). At the same time, a part of compressed air is supplied to air bag (D) for initial height setting of passenger car.

When a moving vehicle encounters bumpy road sections, the height sensor (E) transmits the signal of the relative position between the frame and the wheel to the ECU control box (F). The ECU control box (F) controls the airbag (D) through the solenoid valve (B) based on the control logic that the frame should be at the set level. By inflating or deflating the air bag (D), the frame (chassis) can be kept at the set level as far as possible, and the discomfort of passengers can be reduced.

When the speed of the moving vehicle reaches 90 km/h, the ECU control box (F) will actively output the signal to the solenoid valve (B). The solenoid valve (B) reduces the height of the passenger car site by releasing compressed air in the air bag (D). Through this control mode, the stability of the car body is increased, and the comfort of passengers and the stability of the driver's operation are also increased.

When there are high obstacles in the driving section, the driver can lift the frame by manually controlling the remote control (H). When the ECU control box (F) receives the signal transmitted by the remote controller (H), it will output the signal to the solenoid valve (B). The compressed air in the air reservoir (C) is conveyed to the air bag (D) by the solenoid valve (B), so as to lift the frame. That is to make the vehicle run normally and pass through this section.

3. Basic situation of air suspension system
The air suspension system has improved a lot in comfort compared with the double-arm and multi-link independent suspensions, but there are also some corresponding defects: 1. Increasing the layout space; 2. Increasing the failure point of the suspension system. The main reason is that the air suspension system involves many products, so the layout space is increased. It is also because of the increase of products that the failure point increases. With the increase of layout space, most of the air suspension systems can only be arranged on medium and large passenger cars or SUVs. Although the failure point of suspension system has increased, the main failure point is oil-free air compressor (A), and the limitation of working time of oil-free air compressor (A) is the main reason. Therefore, increasing the use time of oil-free air compressor (A) has become the focus of the air suspension system. The structure of oil-free air compressor (A) determines that it can’t be in the state of gas supply for a long time, because in the state of gas supply for a long time, the motor needs to work for a long time, which will generate relatively large amount of heat and easily cause the failure of oil-free air compressor (A). However, prolonging the time between the two air supply of the oil-free air compressor (A) will make
the gas storage capacity inside the air reservoir (C) unable to supply the air bag (D) at the later stage, thus reducing the comfort of passengers. This requires us to balance the use time of oil-free air compressor (A) with passenger comfort and find a better control logic. At the same time, it is necessary to find some unnecessary air consumption of passenger cars in the course of driving and remove them, which can also increase the use time of oil-free air compressor (A). The purpose of using air suspension is to increase the comfort of customers, so it is not advisable to extend the time between two air supply of oil-free air compressor (A). The only thing that can be done is to find some unnecessary gas consumption in the course of driving.

4. Damping mode of air suspension system

If the vehicle is on a relatively smooth road, the height sensor (E) transmits the height information of the body to the ECU control box (F) in real time, and the ECU control box (F) adjusts the height of the airbag (D) by controlling the solenoid valve (B) in real time, so that the body is at a fixed height and passengers can experience the comfort of riding. The amount of gas used in this process is very small, so it will not burden the oil-free air compressor (A). Assuming that the vehicle is in a bumpy road section and continues to use a smooth road section (real-time feedback), the air consumption of the air suspension system will be very large, because the fluctuation of each road surface will cause a burst of air bags. And for bumpy sections, real-time feedback processing will increase passengers' discomfort. The ECU control box (F) lowers the height of the airbag (D) in the starting section, but suddenly when the next section is a volt section, the car body will be lower, making the passenger drop higher. So we need to adopt different treatment methods when dealing with bumpy sections, which we call damping treatment. The so-called damping treatment is the real-time feedback and delayed response. The height sensor (E) transmits the height information of the body to the ECU control box (F) in real time. The ECU control box (F) evaluates the information transmitted by the height sensor (E) in a short time to determine when to control the solenoid valve (B) to adjust the height of the airbag (D). This control logic can not only maintain the comfort of passengers as much as possible, but also reduce the air consumption to maintain the service life of oil-free air compressor (A). Because different vehicle speeds, road conditions and vehicle's own state will affect the air suspension system, the better control effect can only be achieved by collecting test data.

![Fig. 2 Basic Structure Sketch of ECU](image-url)
5. Conclusion
Damping mode of air suspension system affects the safety and comfort of the whole air suspension system, so the study of this project can help to improve the whole air suspension system to a great extent, besides it helps a faster application of the system in market.

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