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Comparative study on the transmission characteristics of air spring suspension and traditional suspension of a certain vehicle model

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Abstract

At present, air spring suspension has gradually become popular in different vehicle models of car companies. In order to explore the similarities and differences in transmission characteristics of different suspension forms, this article takes the transfer function from the axle head to the vehicle body as the research object. For the high and low configuration versions of the same vehicle model, sweep frequency excitation is carried out on a four pillar platform to obtain the response signals of the axle head and the vehicle body, and the corresponding transfer function is calculated. By analyzing the transfer characteristics, Thus, the difference in transmission characteristics between air spring suspension and ordinary suspension can be quantitatively analyzed. The conclusion of this study can provide a basis for analyzing the root causes of interior resonance and abnormal noise problems of different vehicle models.

Keywords

Air spring suspension; Transfer function; Four poster; Sweep frequency excitation.

1. Introduction

With the development of automobile electrification, intelligence and connectivity, products are rapidly iterated, and the comfort of automobiles has become the focus of product competition. As a better solution, air spring suspension has become increasingly widely used in automobiles despite its relatively complex structure, high manufacturing technology threshold, and high cost, because it has many features that cannot be replaced by other forms of suspension. Excellent performance, for example, the natural frequency of the air suspension can be appropriately changed as needed; the stiffness changes with the load, and the natural frequency is not affected by the load; the high-frequency filtering effect is good, which is beneficial to improving the NVH performance of the vehicle; it is beneficial to reduce the vehicle's NVH performance Damage to the road surface and improve the reliability of automobile assembly components, etc. [1,2]

This article focuses on the same vehicle model. Sensors are installed in the load transfer path of the vehicle. The wheel-coupled road simulation test bench can provide a uniform frequency sweep signal to the entire vehicle to excite the entire vehicle. The same input load excitation ensures a single variable input for the entire vehicle test. Thus, the vibration signals at each point on the transmission path are obtained, the corresponding transfer function is calculated, and the transmission characteristics of different suspension forms are analyzed to quantify the differences between different suspensions [3,4] ..

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2. Theoretical analysis

2.1. System frequency response function identification.

The four-channel road simulation test bench is not an absolutely linear system. There is a certain amplitude and phase difference between the command signal and the actual displacement of the actuator. Therefore, it is necessary to use the frequency sweep excitation signal as the target and the drive signal of the actuator as the response. signal, the system error is eliminated through the iteration principle, so that the driving signal of the actuator is consistent with the target excitation signal.

The basis of data iteration is R PC control technology, which is mainly used to reproduce the vibration and motion forms of samples in the actual mechanical environment to the laboratory environment. RPC technology is mainly used to convert the expected response signal into the driving signal of the equipment. It can compensate for the performance attenuation of the hydraulic system, solve the coupling problem between each channel, and ensure that the amplitude and phase of the signal remain accurate .

The system frequency response function (FRF) is a mathematical model that tests the relationship between the input signal and the output signal of the system. The purpose of solving FRF is to test the stable approximate relationship between the system input (Input) and output (Output) signals at each desired frequency. For this study, the command signal of the actuator is defined as the input (random excitation signal, Drive) in the test system, and then the actual displacement signal of the actuator is measured as the response signal (Response) and the signal is Fourier Leaf transform solves the mathematical relationship between the input frequency domain signal and the response frequency domain signal, and finally obtains the system frequency response function.

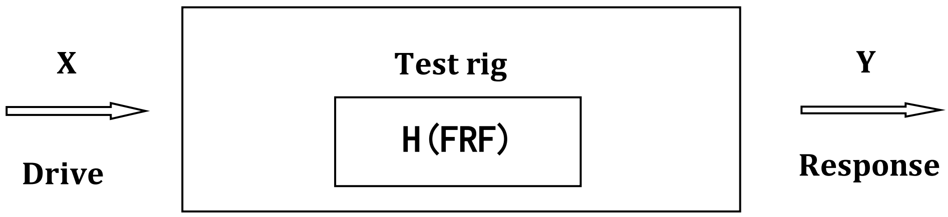

Fig. 1 System frequency response function model

2.2. Transfer function definition and analysis method.

The transfer function is an important parameter for the evaluation of suspension vibration reduction effect and a technical reference method for vehicle anti-resonance design. The dimensionless ratio of the transfer function response amplitude to the excitation amplitude is similar to the system frequency response function mentioned in the previous section of the system. Can be a ratio of load, displacement, velocity or acceleration. As long as the stiffness meets the requirements, the smaller the transmissibility, the better the transmission effect and the better the vibration absorption effect. The larger the transmissibility, the easier it is to produce resonance and the worse the vibration reduction effect. The frequency corresponding to the peak value of the transfer function is the natural frequency of the elastic element. (Resonance frequency). The influence of transfer function and natural frequency is of great significance. The transfer function is similar to the frequency response function of the road simulation system. The transfer function takes the axle head acceleration as the system input and the body shock absorber tower package position as the system output. The relationship between the input and the output is calculated to obtain the suspension transfer function. [5,6,7,8].

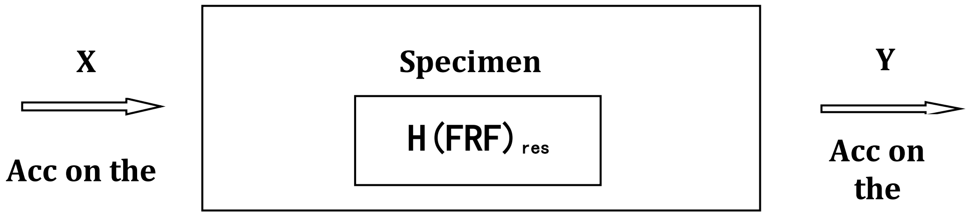

Fig. 2 Suspension transfer function model

2.3. Sweep excitation.

The Sine swept road excitation can be used to analyze the vibration frequency response characteristics of vehicle suspension systems.

$$x_r(t) = A\sin(2\pi\lambda t^2 + \theta)$$

In the formula: $\lambda$is the sweep rate, $f=\lambda t$, which means that the frequency of sinusoidal road excitation increases linearly with time. An example of the sinusoidal swept road excitation time domain curve is shown in the Fig.:

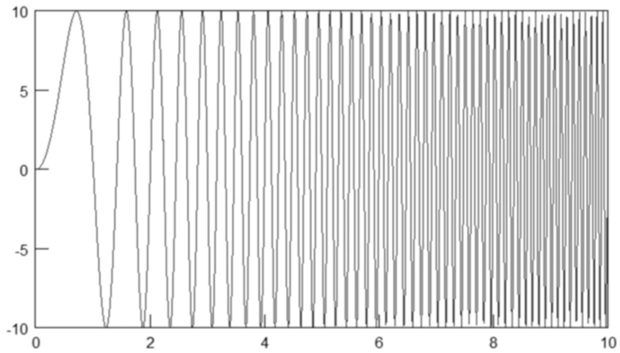

Fig. 3 Time domain curve of frequency sweep sinusoidal road excitation

According to the frequency change rules, the sine frequency sweep test is divided into a linear sine frequency sweep test and a logarithmic sine frequency sweep test. This article uses a linear sine frequency sweep test, so a brief introduction to linear frequency sweep is given. Linear sine frequency sweep test refers to a frequency sweep test in which the frequency of the excitation signal changes linearly. It is mainly used in sinusoidal slow scan tests for accurate identification of product modal parameters. For system components such as the entire vehicle, which is composed of complex components, the sinusoidal slow scan modal test is mainly used to analyze the vibration isolation characteristics of the suspension system [9,10].

This paper uses a constant velocity sweep signal as the excitation signal for experiments. The constant speed sweep input speed curve is shown in the Fig.:

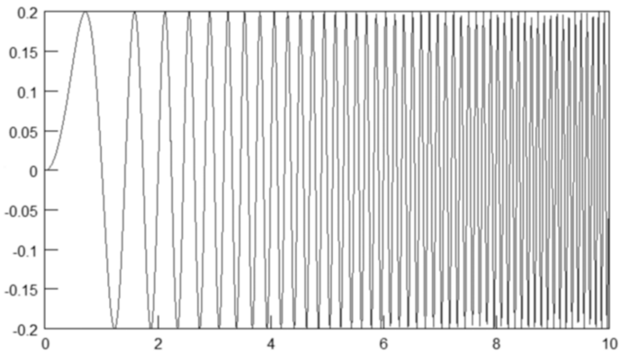

Fig. 4 Constant speed sweep speed curve

3. Test verification

3.1. Bench construction

The vehicle ride characteristics test was carried out on a four-channel road simulation test bench. According to the conventional test requirements, the entire vehicle was counterweighted. The main driver and passenger driver were each counterweighted 75 kg. Before the test, acceleration sensors were installed on the wheel axles . The position of the head and shock absorber tower package, and the sensor location are shown in the Fig. below . The test direction is vertical, and the upward signal is positive.

Fig. 5 Position of accelerator on axle

Fig. 6 Position of accelerator on topmount

3.2. Test input

The frequency swept road surface contains continuous frequency components. Therefore, this article uses the commonly used constant speed frequency sweep signal. The test condition input is: maximum speed 100mm/s, frequency sweep range 0.5~30Hz, and maximum amplitude of road unevenness 32mm.

The road speed spectrum of the constant speed sweep input is a constant, which is similar to the spectrum composition of the actual road. The response spectrum obtained is similar to that of the random road.

The surface response spectrum is close in composition (the difference is mainly reflected in the amplitude), and the vibration response is closest to the actual vehicle test. The actuator driving signal of the constant velocity sweep signal is shown in Fig. 7 .

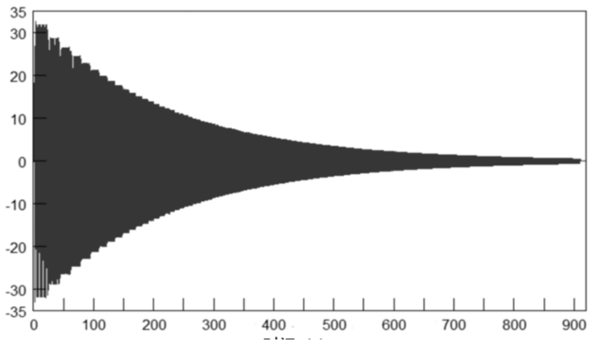

Fig. 7 Drive signal

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Taking the frequency sweep excitation signal (that is, the generated frequency sweep drive target signal) as the target, iterate the most responsive actuator signal of the four-channel road simulation test equipment. The iteration error RMS is shown in Fig. 8. The final result of the root mean square error is less than 1 % , which is a relatively ideal result.

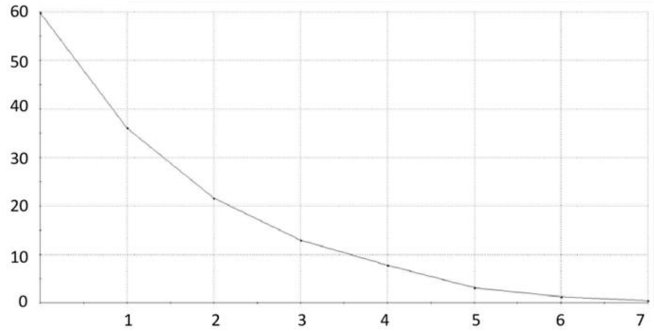

Fig. 8 Driving signal iteration root mean square error results

3.3. Test results and analysis

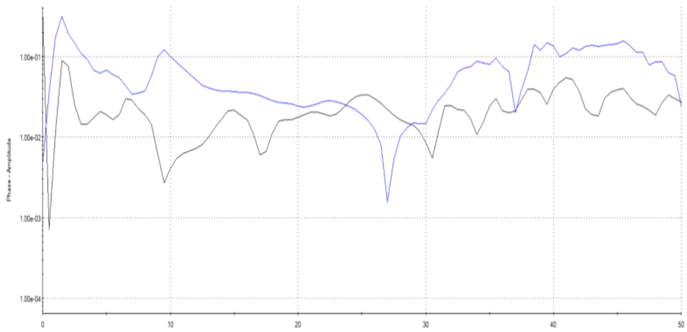

Fig. 9 Transfer function from shaft head to topmount

The solid and dotted lines in the Fig. represent the transfer functions from the axle head to the topmount of the air spring suspension and traditional suspension respectively. It can be clearly seen that under the same frequency sweep excitation, the transfer functions of the two are quite different. Overall, the vibration isolation rate of air spring suspension is significantly better than that of traditional suspension. The vibration isolation effect is not obvious in the low frequency band around 2.5Hz, and the vibration reduction effect is very obvious in the main frequency of general bad roads around 10Hz. In the high frequency band, there is not much difference between the two due to the smaller amplitude.

4. Conclusion.

Based on a four-channel road simulation test bench , this article compares the transfer functions from the axle head to the topmount of air spring suspension and traditional suspension through frequency sweep tests . The vibration reduction effects of air spring suspension and traditional suspension at different frequencies are obtained. It provides a good research basis for subsequent research on the resonance of different suspensions on the car body and interior and exterior trim parts.

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