Research on optimization control of vehicle road noise performance

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Abstract. By analyzing the road noise problem of a car model, it is confirmed that the car exists in the car when driving at uniform speed on rough road surface. The front and rear row road noise problem. Based on the existing vehicle CAE model, the TPA analysis of the vehicle model was carried out by using MSC NASTRAN software to obtain the contribution of each transfer path to road noise, and the main path influencing the road noise was locked. The key factors on the main path are further identified through acceleration response analysis of key positions in the transfer path. Through vehicle test and ODS simulation analysis, the main vibration modes of the components that affect the road noise are determined. Combined with CAE and test methods, a reasonable chassis optimization scheme was developed to improve the road noise performance of the vehicle.

Keywords: Road Noise, MSC Nastran, Transfer Path Analysis

1. Introduction
With the rapid development of automobile industry, consumers have more and more profound understanding and higher requirements for NVH performance of automobiles. According to the results of the vehicle owners' satisfaction survey, the road noise in vehicle running has a strong response, which seriously affects the comfort of the vehicle. A high quality vehicle must have good road noise performance characteristics, so in the process of vehicle NVH performance development, the study and control of road noise problem is very important. In this paper, aiming at the road noise problem of a car model, through the method of transfer path analysis, MSC NASTRAN software was used to analyze the transfer path based on the vehicle CAE model to lock the main energy contribution path for the connection point between front and rear suspension and body. Through the acceleration response analysis of the key positions of the main path, the key factors affecting the front path impetuosity were identified. Through ODS test and CAE analysis, the main contribution components and modes of vibration affecting the rear circuit were identified. Thus, the performance of road noise is optimized.

2. Analysis of road noise problem
The front suspension of a car is McPherson type independent suspension, and the rear suspension is multi-link independent suspension. When driving at uniform speed on rough road, there is obvious rumbling sound in the front and rear, which seriously affects the comfort of the car and directly affects
The NVH performance of the car. The objective test of the vehicle on the rough road at a constant speed of 60km/h shows that there is obvious noise peak in the front and rear of the vehicle near the sound mode of 220Hz tire. The objective test data is shown in Figure 1, and the subjective feeling is very poor. Note: the red solid line is the front row noise test data of this model, and the green solid line is the rear row noise test data of this model.

![Figure 1. Interior road noise test results](image)

3. Mechanism of road noise generation

Road noise is mainly generated by road excitation of tires in the process of vehicle running. According to different transmission paths, road noise can be divided into air-borne noise and structure-borne noise. The main mechanism is as follows: the tire tread and the road cavity form an "air pump effect", when the tire contact the ground, the air gathered in the tread or the road cavity is squeezed and suddenly outflow, when the tire leaves the road connection. When touching the surface, air will suddenly flow in, and noise will be generated in this process of "air pump effect", which is mainly transmitted into the car through air [1, 2]. The structural noise generated by the road excitation on the tire comes from two aspects: on the one hand, the vertical force generated by the continuous local compression and release of the tire through the road surface; on the other hand, the longitudinal exciting force generated by the continuous rolling and release of the road surface and the tire rubber on the contact surface. The road excitation force on the tire is transmitted to the axle through the coupling system between the tire cavity and the rim, and from the axle to the chassis suspension system, and then to the body and into the car [3, 4].

4. TPA simulation analysis of vehicle road noise

4.1. TPA analysis of front road impingement simulation

As shown in Fig. 2, in the analysis of transfer path contribution, the right X direction (vehicle Y direction) of the leading point of the lower control arm of the front suspension accounts for 188% positive contribution, and the left Y direction (vehicle Z direction) of the leading point of the lower control arm of the front suspension accounts for 34% positive contribution. That is, the left and right front points of the lower control arm of the front suspension jointly lead the 220 path impetuance problem.
Figure 2. The analysis results of the contribution of TPA path in front road

4.2. TPA analysis of rear-circuit manic simulation

As shown in Figure 3, in the analysis of transmission path contribution, the Y-direction (vehicle Z-direction) of the right towing arm of the rear suspension accounts for 81% of the positive contribution, which plays a major role in the problem of 220 road disturbance in the rear. It can be seen from Figure 4 that the bushing unit force of the right rear towing arm is much larger than that of other paths, that is, the excitation force of the rear towing arm is too large.

Figure 3. Analysis results of path contribution of impulsive TPA in back road

Figure 4. Rear - road manic TPA unit force analysis results
4.3. Rear - road manic test and simulated ODS analysis

The vehicle ODS test was conducted to analyze the frequency of rear road disturbance problem, and the results were shown in Fig. 5. The vehicle's vibration in the Y/Z direction was obvious, and the simulation analysis results were also corresponding to it.

Figure 5. Results of ODS analysis of rear - road manic test

5. Conclusions

The vehicle TPA analysis was carried out by using MSC NASTRAN software. Critical position acceleration response analysis and ODS analysis method, through the combination of simulation and experimental analysis, the following conclusions are drawn:

1. Using the analysis and calculation results of TPA, accurate locking the main contribution path of the interior road noise problem.

2. Using the results of acceleration response analysis of key positions, we can accurately lock the key positions (key influencing factors) under the main contribution path of road disturbance, especially when there are three, four or even more links in the same contribution path, which has important guidance significance. If combined with the application of the interior body superunit, the optimization efficiency of the chassis against road noise will be greatly improved.

Acknowledgements

The research was financially supported by the National Natural Science Foundation of China (51275541).

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