Simulation Analysis of Automobile Air Suspension Dynamics based on ADAMS

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Abstract. Analysis for the dynamic simulation of air suspension, rear suspension of avehicle is selected as the main research object. Related to simplify the vehicle model,the establishment of 1/4 vehicle models in ADAMS. Then according to the passive suspension and air suspension, analysis of the acceleration of sprung mass, dynamic rate of suspension and wheel dynamic load. A verification installationwith air spring of heavy automobile independent suspension for the role after the ride comfort and road friendliness of promotion and performance on the total target vehicle lifting effect.

Introduction

Thomson Lotus company is in in the early eighty century produced the first car with active suspension prototype prototype, the basic idea of active suspension is improved. Ford car at the end of 84 the company's Uncontinental car adopt selectronic control air suspension system, so as to effectively realize the height adjustment and vibration isolation. Japan's Toyota Auto Body Co in 1983 Soarer carassembly of shock absorber with adjustable damping. In recent years, our country has carried out some research on air suspension, but in the use of air spring rate of our country is still in a relatively backward stage. This paper studies the selection of dynamic simulation analysis of a heavy duty truck rear suspension as the main research object, because of its transport in the process of carrying the main load-bearing body, so the focus is on the vehicle ride comfort and road friendliness in the simulation was performed before, to determine the effective target function and the establishment of road input model and prototype the reasonable model.

The vehicle ride comfort and road friendliness of ascension as a dynamic simulation analysis of target. The main evaluating indexes of ride comfort for the body acceleration, suspension dynamic deflection value and wheel dynamic load. Selection and evaluation of ride comfort of the sprung mass acceleration RMS $f_1(x)$ as the main target, a secondary goal for suspension travel RMS $f_2(x)$, and tire dynamic load as these condary targetc $f_2(x)$. The objective function is established as shown in formula (1):

$$F_1 = a_1 f_1(x) + a_2 f_2(x) + a_3 f_3(x) \quad (1)$$

Set the main goal of the sprung mass acceleration RMS $f_1(x)$ weight coefficient $a_1 = 0.5$, a secondary goal suspension travel root mean square value $f_2(x)$, weight coefficient $a_2 = 0.3$, dynamic loadco efficient $f_3(x)$, the secondary target tire weight $a_3 = 0.2$.

The road friendliness with three main evaluation indexes: road stress factor, dynamic load coefficient and 9500 points four times the power and force[1]. When the tyre dynamic load standard deviation σ , mean and the 95 percentile $\mu + 1.65\sigma$. 95 of which four times the power and force of the concrete calculating formula[2]:

$$\varphi = \left[\eta_1 \eta_2 (1 + 1.65 DLC) P_s\right]^4 \quad (2)$$

In the formula:

η_1 as the tyre layout influence coefficient, Unilateral single tire 1

η_2 as the inflation pressure influence coefficient of tire, the tire pressure is selectedaccording to the actual;

The η_2 value is 1; p_s for static load tire. Where DLC [3] is the dynamic load coefficient of tire.

This evaluation method is defined on the basis of theory of road damage coefficient J:

$$J = 1 + \frac{1.65\sigma_{A^4}}{m_{A^4}} \quad (3)$$

In order to verify the comprehensive performance of suspension ride comfort and road friendliness of improvement, to determine the general objective function F are as follows:

$$F = \beta_1 F_1 + \beta_2 \varphi \quad (4)$$

β_1 , β_2 is the weight coefficient, to balance suspension ride comfort and road friendliness, set $\beta_1 = \beta_2 = 0.5$, F1 harshness as objective function, the formula (2) in the road friendliness ofevaluation index 95 points four times the power and force[4].

The establishment of road model

The establishment of road simulation model is shown in Fig.1 in the MATLAB. Because our country highway is based in A, B, C, D levels within the range, this paper selects B level road, the speed of 60km/h, the time domain signal is obtained, as shown in Fig. 2, the road excitation time domain signal into ADAMS.

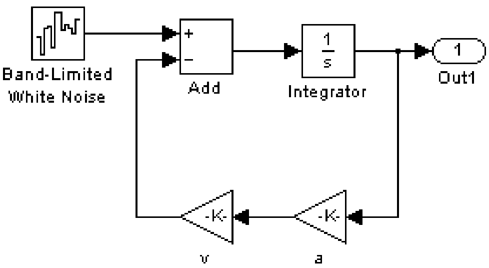


Fig.1 Road simulation model

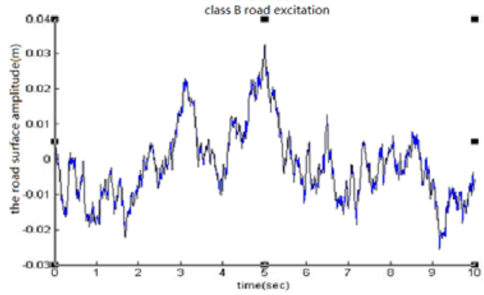


Fig.2 B level road 60Km/h road irregularity excitation signal time domain simulation

The air suspension dynamics modeling

This paper selects a heavy-duty truck rear suspension as the foundation, followed bythe suspension spring mass is 7000Kg, because the air spring suspension in the airthe leverage ratio is 3 and the analysis of 1/4 vehicle models, after computing the suspension of unilateral load is 2625Kg, the unsprung mass 260Kg. The selected IT19F-7 air spring load range of 1540-4210Kg.

The establishment of 1/4 vehicle models with ADAMS/View module, key point positionaccording to the suspension, suspension of 1/4 vehicle models established in Fig. 3.

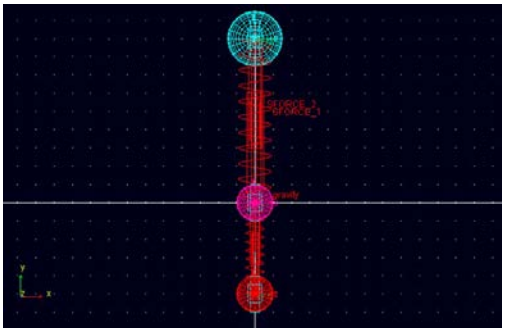
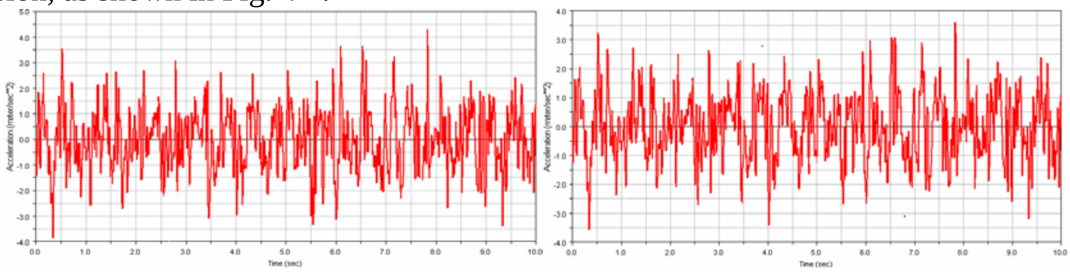


Fig.3 The 1/4 vehicle model based on ADAMS

Analysis of dynamic simulation of air suspension

According to the pavement model established, respectively set selectedpassive suspension and air suspension model, the simulation analysis of the selected models the load condition of the rear suspension, as shown in Fig. 4[5]:



Passive suspension Air suspension

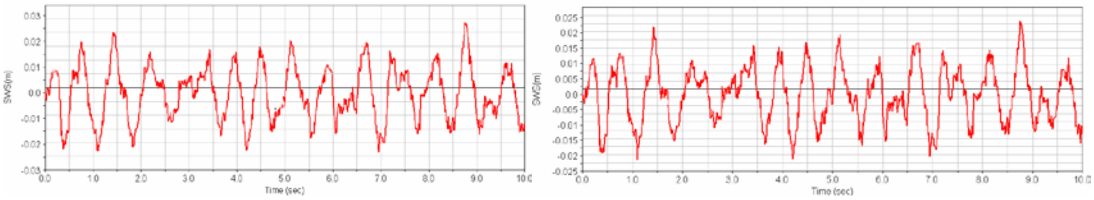
Fig.4 The acceleration of sprung mass

According to the simulation results can be seen in Fig. 4, two different suspensionacceleration of sprung mass differences, with the acceleration of the sprung mass andthe maximum value of sprung mass acceleration RMS do numerical index contrast, see table 2.

Table 2 the two suspension of sprung mass acceleration value comparison

The parameter name	Passive suspension	air suspension
The maximum value of the acceleration of sprung mass a_{max} / （m·s-2）	4.28	3.59
The sprung mass acceleration RMS $\sigma_{\ddot{z}}$ / （m·s-1）	1.28	1.18

Can be seen from table 2, the passive suspension, the acceleration of sprung mass to a maximum of 4.28 S-2 m, exceed the limit of ride comfort to allow the value of the0.3g~0.4g range, air suspension, the acceleration of sprung mass to a maximum of 3.59 m S-2, 16.3% lower than the former, sprung mass acceleration RMS is reduced by 8.6%, improve the ability to protect the goods. Fig. 5 simulation results for travelsuspension of two kinds of suspension system under the:



Passive suspension Air suspension

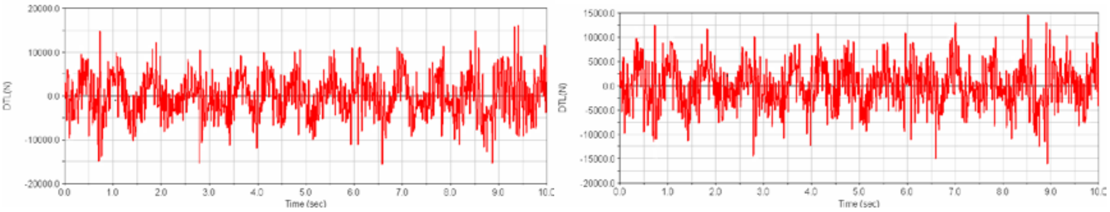
Fig.5 Suspension travel

The simulation results of dynamic suspension travel by two kinds of suspensionsystem, the suspension can be obtained and the corresponding displacement, specific parameters such as shown in table 3.

Table 3 Comparison of suspension displacement parameters

The root mean square value	Passive suspension	air suspension
Suspension dynamic displacementSWS/m	0.0104	0.0086

Can be calculated by the data in the table, air suspension dynamic displacement thanthe passive suspension displacement reduced 17.14%, compared to the traditional passive suspension, air suspension suspension dynamic displacement is reduced effectively, reduces the possibility of limiting block hit, improve the ride comfort of vehicle [6].



Passive suspension   Air suspension

Fig.6 Wheel dynamic load

Fig.6 is the result of dynamic load simulation of two kinds of suspension system under the wheel, using wheel dynamic load RMS do index comparison. Wheel dynamic load change with different control methods, combined with the friendly evaluation indexin this chapter are the relevant parameters evaluation road road friendliness, as shown in table 4.

Table 4 Comparison of correlation parameters of road friendliness

Parameters	Passive suspension	air suspension
The root mean square value of dynamic load of the wheels RMS/N	5061	4571
Wheel dynamic load coefficient $DLC/\%$	14.16	13.08
95 Percentile four power and force $\phi/10^{18}N^4$	3.53	3.26
Road damage coefficientJ	7.17	6.17

From Table 4 of the two suspension wheel dynamic performance parameters aftercontrast load simulation indicate: compared with the passive suspension, air suspension vehicle dynamic load RMS value reduced by 9.72%, vehicle dynamic loadcoefficient decreased by 7.75%, 9500 points four times the power and forcedecreased by 7.15%, 14.07% reduction of road damage coefficient. According to the calculation, compared to the passive suspension, air suspension vehicle ride comfort system promoted 11.38%; compared with the passive suspension, equipped with airsuspension system of heavy-duty car vehicle ride comfort and road friendliness ofcomprehensive performance improvement of 9.26%.

Conclusion

Based on the analysis and evaluation indicators of vehicle road friendliness, both on the ride comfort and road friendliness, establishing the general objective function to determine the target weight. Through the study of road roughness power spectrum, in MATLAB the road input model is established by using filter white noise method.According to the research needs related to simplify the vehicle model, in the ADAMS1/4 model of vehicle is established, then the passive suspension and air suspensionin the pre load cases, respectively analyzes the sprung mass acceleration, suspension travel and vehicle dynamic load, the results show that, compared to thepassive suspension, air suspension vehicle sprung mass acceleration, suspension travel and wheel dynamic load is effectively reduced, the vehicle ride comfort and road friendliness improve.

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