Numerical Simulation on XIALI Car Dynamic Response

Zu Wendong , Wang Yan, Li Jingzhan
Tianjin Automobile Research Institute, Tianjin, China
Tel:022-27030703
Email: lijingzhan@263.net

ABSTRACT

Based on the white body's finite element model, the dynamic response finite element model of TJ7100 car created with MSC.Patran and MSC.Nastran. The body response power spectral density (PSD) is calculated under real road PSD and compared with test result. The finite element model is reliable and can be applied to car response evaluation.

Keyword Finite Element, Dynamic Response, Spectral Analysis

INTRODUCTION

With the rapid development of vehicle CAE application, the main job of vehicle evaluating engineers has been transferred from evaluation of physical prototype to virtual evaluation of digital model during design phase in vehicle industry. By this way, times of physical prototype trial-manufacture is decreased and developing period is shortened. In order to improve product development ability, we have introduced CAE technique for dynamic response evaluation of our product (TJ7100, a model of XIALI car).

CREATION OF WHOLE VEHICLE MODEL

After simulation analysis calculation of white body FE (finite element) Model and comparing the calculation result with that of test, one can find out that the white body FE Model is reliable.

In order to calculate dynamic response under random input, we have to create a precise whole vehicle FE model base on white body FE Model by introducing doors, hood, chassis assemblies, engine, electric accessories and passenger etc. MSC.Nastran is adopted for creation of the model in which concentrate mass element rigid bar element, damping element and spring element are used to simulate some vehicle parts, passenger and suspension system. The model is shown in Figure 1.

VERIFICATION OF THE WHOLE VEHICLE MODEL

After NORMAL MODE calculation of the whole vehicle model, we obtained a series of nature frequencies within 1Hz---50Hz (1.3782Hz, 1.5737Hz, 1.7947Hz, 21.504Hz, 22.314Hz, 24.539Hz, 26.377Hz and 31.837Hz etc.). Taking mode 4th as an example, its nature mode is shown in figure 2. It is easy to find out that the lower nature frequencies (1.3782Hz, 1.5737Hz, and 1.7947Hz) represent the nature characteristics of the suspension system and the others represent the nature characteristics of the body. Taking the 1st nature frequencies as an example, it represents the nature characteristics of a simplified vibrating system where the suspension mass of the vehicle is simplified as a mass point and the suspension system as spring and damp along axle-Z. The nature characteristics of a simplified vibrating system can be calculated directly as following:

$$f=(k/M)^{1/2}/2\pi$$

Where f is natural frequency, k is spring coefficient, and M is Mass. If $k = (15700\times2+13700\times2)=58800(Kg/m)$ and $M \approx 1000Kg$, $f = 1.2204Hz$.

Comparing the calculated result from different methods, the relative error is 11.45%, which may be mainly caused by simplification of the model, and it primarily proved that the whole vehicle FE Model is reliable.

MODIFICATION OF THE WHOLE VEHICLE MODEL

The calculated nature mode can be dynamically displayed by MSC.Patran. If there are some malformations on any nature mode, the reason may be: on one hand, there is really design problem on local part of vehicle (especially during development period), the analysis engineer should discuss the problem with the design engineer about how to solve the problem at this time. On the other hand, the malformation may be caused by improperly simplification during creation of the model, and then the model should be modified. We have removed the malformations that may effect the simulation result based on our experience.

AVOIDING OF RESONANCE

We can find out if there is frequency overlap from the calculated result of NORMAL MODE calculation. Resonance can be avoided by modify frequency distribution during development period.

EDITION OF ROAD LOAD INPUT SIMULATING FILE

In order to simulate the vibration of vehicle running on the road, the road exciting power spectrum applied to wheels should be recorded and taken as input for calculation theoretically. However, the power spectrum of the axle end is recorded during test on road and it is also used as expecting response signal for test on MTS road load simulating system, so we take it as input for simulating calculation. The MSC.Nastran required input file is obtained by editing the file from MTS system.

THEORY OF RESPONSE SPECTRUM CALCULATION

We have introduced multi-input and output system for precise calculation of spectrum output on any part of vehicle. Base on theory of random vibration, the relationship between input power spectrum and output power spectrum can be described by the following equation:

$$[W(f)]_{n\times n} = [H^*(f)]_{n\times s}\,[S(f)]_{s\times s}\,[H(f)]^T_{s\times n}$$

where:

n—Degree of model, MSC.NASTRAN can determine the degree of the created model automatically

s—Degree of input, for a four wheel car s equal 4

$[S(f)]_{s\times s}$ —Input power spectrum matrix, it includes auto spectrum and mutual spectrum of 4 wheels. The MSC.NASTRAN can calculated the PSD function according to the input file above described.

$\left[H^{*}(f)\right]_{n\times s}$ —Conjugation of frequency response function matrix $\left[H(f)\right]_{n\times s}$

$\left[H(f)\right]_{s\times n}^{T}$ —Transition matrix of frequency response function matrix $\left[H(f)\right]_{n\times s}$

If the node of FE Model is created properly, the power spectrum output of any part on vehicle can be calculated basing on above described theory.

EDIT OF PRIMARY MODEL DATA FILE

The primary model data file for analyzing can be edited by MSC.Patran or MSC.Nastran according to which you prefer. We edited the primary model data file using MSC.Nastran which can call the data file of white body model directly.

THE RESULT OF CALCULATION AND TEST

We have obtained output power spectrum of front right supporter of driver's seat on floor under road load power spectrum from calculation and test (See Figure 3. and Figure 4.). Based on the two curves we can find out that the outputs of both methods have two obvious main peaks, the first peak is higher than the second one and frequencies of peaks are quite the same. The first peak shows that there is frequency overlap between road load and suspension system and the second peak shows that between road load and wheel. In the same time, we can find peaks over 20Hz that shows nature characteristics of body and they are much smaller, however, if there were resonance, they will become more important for study.

CONCLUSIONS

According to above expatiation, we have created a correct FE Model for calculation of dynamic response under road load exciting input and modal analysis. The method can be used evaluation of ride ability and structure dynamic rationality during for new product development design phase.

REFERENCES

? MSC.Nastran User Mannul, Version 70, MSC.Software Corporation, Los Angeles, CA, 1998

? MSC.Patran User Mannul, Version 70, MSC.Software Corporation, Los Angeles, CA, 1998

? Wang Yan and Li Jingzhan, "Whole Vehicle Vibration Response Analysis of XIALI Car" , Study report of Tianjin Automobile Research Institute,1999.

? Huang Shilin. “Engineering Signal Process”, Renmin Communication Press,1986.
? Yu Zhisheng, “Automobile Theory”, Machinery Industry Press, 1990.
? Zhou Wei, “Acquisition and Edition of Vehicle Road Load Power Spectrum” , Test Report of Tianjin Automobile Research Institute,1997.

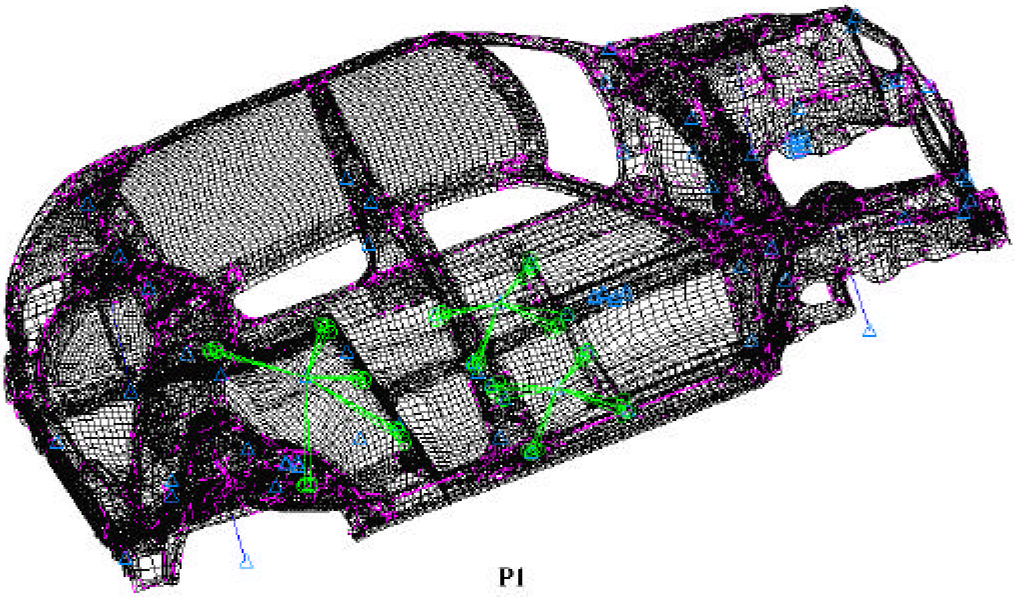

Figure 1. The whole vehicle FE model

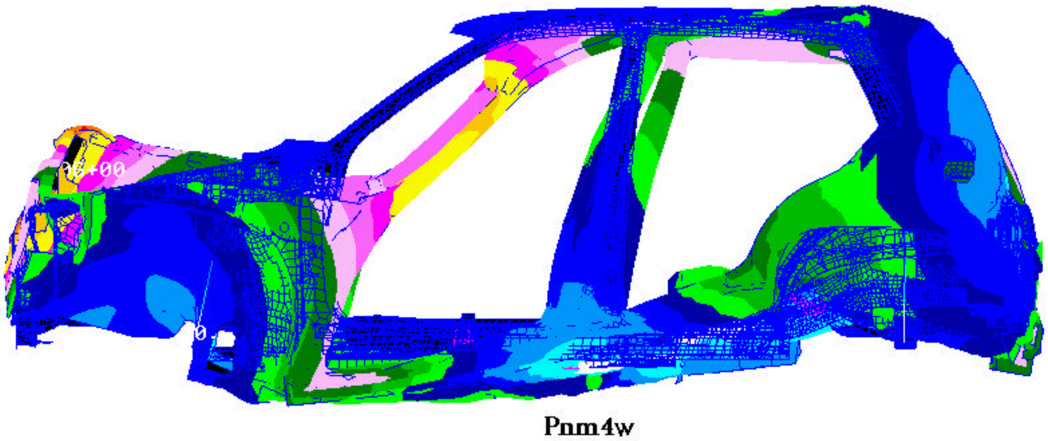

Figure 2. The 4th nature mode

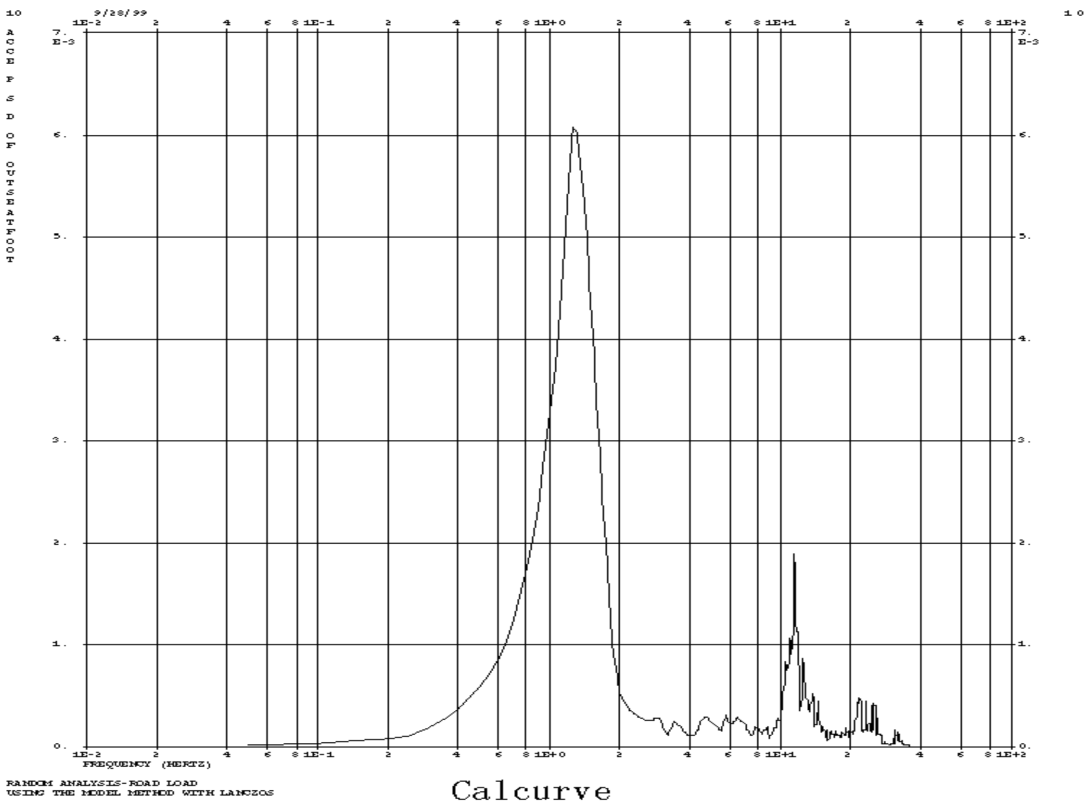

Figure 3. The result of calculation

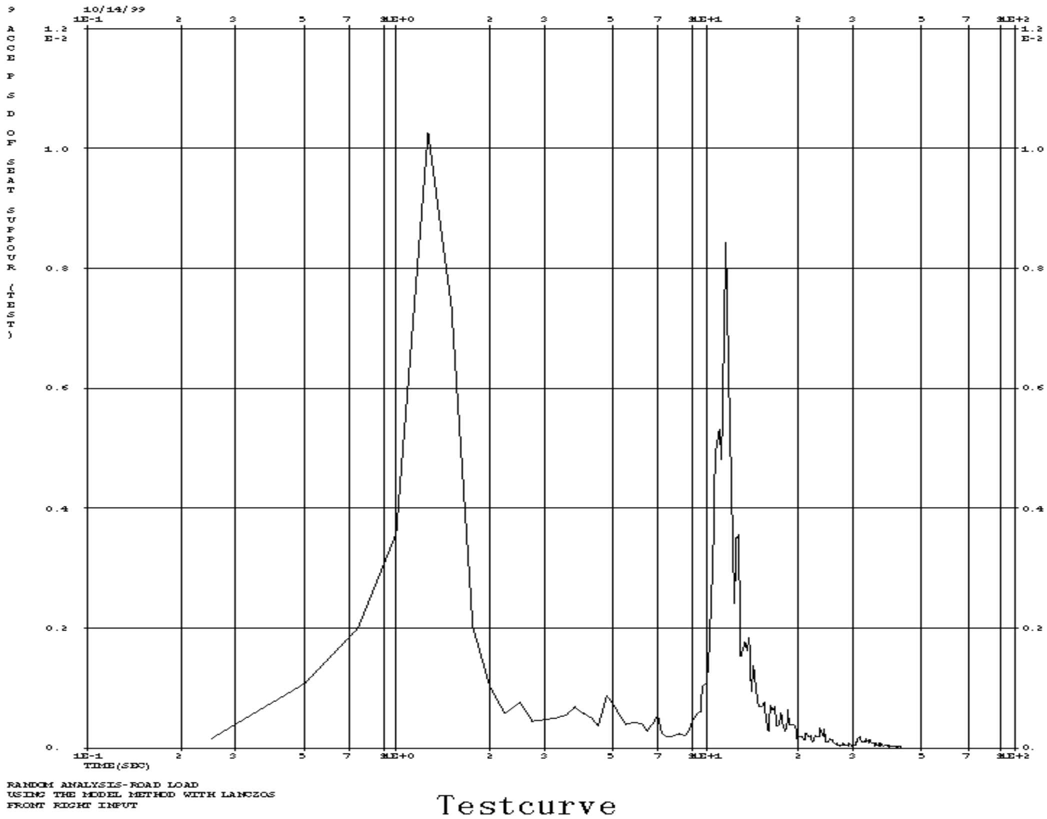

Figure 4. The result of test