The Optimization Design of Mounting System Based on GUI

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Abstract. Automotive power assembly vibration is one of the major automobile vibration excitation sources, which has a significant impact on automotive NVH characteristics. Reasonable power assembly mounting system can reduce the bidirectional transmission of vibration and improve ride comfort. This thesis is the use of a GUI programming, and by analyzing the energy decoupling degree of power assembly mounting system and natural frequency to optimize the design structure parameters of suspension.

0. Introduction

To withstand weight of the power device and the force from the engine torque, the suspension must have sufficient stiffness[1]. If the stiffness of the suspension is low, the power train equipment generates a large displacement, which may occur the interfere with movement of other parts, and also affect other assembly parts mounted on the power device, therefore, at low frequencies, requiring the suspension stiffness should be large.

1. Model building

This thesis mainly is to select a certain four-point suspended models as a reference for modeling. To obtain a good vibration isolation effect, when carry the dynamics analysis of the power plant isolation problem, must obtain the optimal suspension characteristics and installation location.[2] Under normal circumstances, the body is much larger than the stiffness of suspension stiffness, Under normal circumstances, the body is much larger than the stiffness of suspension stiffness, in order to simplify the analysis, often considered as a body with an infinite mass and stiffness of the system, and simplify the power assembly mounting system as a six degree of freedom rigid body vibration model as shown Figure1.
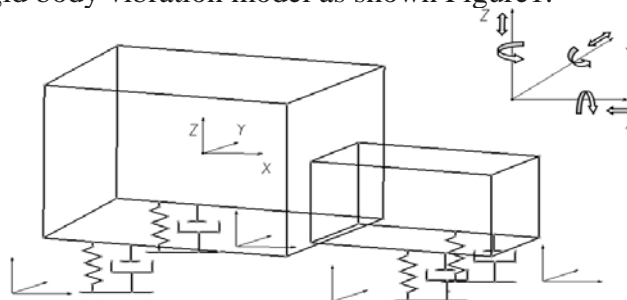

Fig.1.The six degrees of freedom vibration isolation system of power plant

Combined the kinetic and potential of engine system using the Lagrange equation to write the free vibration differential equation of system:

$$[M]\{\ddot{x}\}+[C]\{\dot{x}\}+[K]\{x\}=\{0\} \tag{1}$$

Considering the damping of suspension system is small and its main role is to reduce the resonance peak, it can be omitted at small vibration effect. The system of differential equations:

$$[M]\{\ddot{x}\}+[K]\{x\}=\{0\} \tag{2}$$

In the type: The system inertia matrix M; the damping matrix C; the stiffness matrix K; the generalized acceleration $\ddot{x}$; the generalized velocity $\dot{x}$ and generalized coordinate column vectors x

The formula (2) converted to the frequency domain, can be obtained:

$$(K-\omega^2 M)\{x\}=\{0\} \tag{3}$$

Formula (3) as modal analysis, the natural frequencies and mode shapes of systems are available under various modes.

2. Suspension optimization

Use GUI programming to optimize the calculation of the suspension, the first to determine the optimization objective function and constraints, etc., in the mathematical model with the power train, suspension system natural frequency can be rational allocation and suspension systems decoupling of energy in all directions as optimization index.

(1) The suspension system energy decoupling objective function

For the power assembly mounting system, there are six degrees of freedom of its coupling phenomena, the response of the suspension system of the six directions or all decoupling partial decoupling, so that a mode of the processing time will not affect another mode, but generally difficult to achieve all of the decoupling, Partial decoupling method is often used for optimization.

(2)Natural frequency of the suspension system is configured objective function

Combined with the actual situation and under the various operating state of the engine and road vibration excitation frequency excitation frequency, The principle of the suspension system through the analysis, the natural frequency of the suspension system should generally be set within the range of 5-25Hz[3]. In this paper, the natural frequency of the suspension system ranges from 6 Hz to 18 Hz.

3. GUI design

3.1 Interface design

As shown in Figure 2, through this interface design, you can choose three-point and four-point formula for the number of different engine mounting points, by taking the initial structural parameters measured to obtain the mass and stiffness matrices , And thus, to calculate the natural frequency of the suspension before optimization, mode shapes, the energy matrix and power train in x, y, z, θ_x, θ_y, θ_z of the six degrees of freedom the energy coupling[5]. As shown in Figure 3, setting the upper and lower ranges for each suspension of the three stiffness, Considering the road excitation frequency and excitation frequency of the engine on the six degrees of freedom suspension, all directions ranging from the vertical of the natural frequency is set. This as a constraint of the suspension optimization, the suspension structure parameters can be optimized.
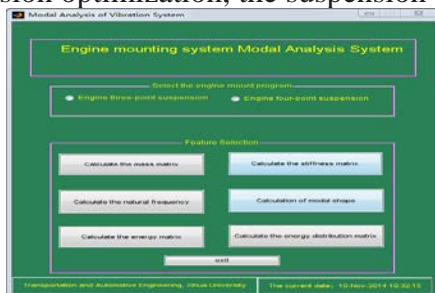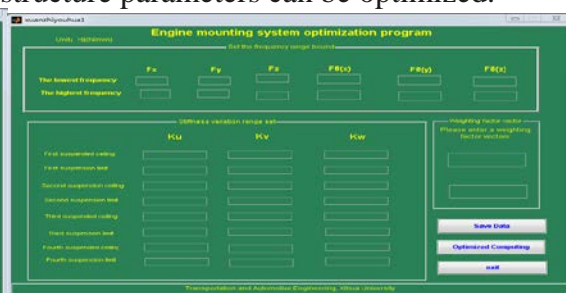

Fig.2. Function Module   Fig.3 .Suspension optimization

3.2 Program Design

In the process of writing the program, mainly through the function of Matlab optimization toolbox to optimize the suspension structural parameters, the respective objective function and constraints are set up as a separate custom functions. So that in the process of computing, can be called multiple times, simplify the programming, faster completion of the optimization process[4]. The simple introduction of the main content and functionality for each defined functions:

Program gongnengmokuai.m function: The program is mainly the use of the initial parameters for mass matrix, stiffness matrix, natural frequency and extent of solving energy coupling.

Program xuanzhiyouhua1.m function: The program is mainly a function of application optimization, constraint functions and objective function to solve the optimization of the suspension structure parameters.

Program four_k.m function: This function is mainly applied to the objective function of the optimization toolbox, as its calling function optimization.

Program fun.m function: This function is used as the constrain function in optimization function. The range of the natural frequency in the various degrees of freedom is as a constraint optimization.

4. Examples of verification

In this paper, the initial parameters of the power assembly is selected for a four-point suspension:

Table1 the quality and centroid position coordinates of the power train

Name	Powertrain Quality	The centroid coordinate position		
Unit	Kg	XO/mm	YO/mm	ZO/mm
Values	186.36	107.99	-40.76	67.84

Table 2 the powertrain moment of inertia

$J_X/Kg \bullet m^2$	$J_Y/Kg \bullet m^2$	$J_Z/Kg \bullet m^2$	$J_{XY}/Kg \bullet m^2$	$J_{YZ}/Kg \bullet m^2$	$J_{XZ}/Kg \bullet m^2$
5.5983	13.0213	11.2954	-0.1996	0.0103	-1.2033

The above-mentioned initial data into GUI suspension function module shown in Figure2, Natural frequency and decoupling of the energy can be obtained as shown in Table 3 before suspension optimization:

Table 3 the percentage distribution of the modal energy power plant before optimization

Natural frequency		23.7269	17.0091	12.2942	9.5577	4.5638	5.5020
Energy Amount of Hundred Branch Ratio	x	0.1140	0.3277	19.1073	11.9768	68.4653	0.0090
	y	1.4235	4.5119	53.3826	10.2537	28.9531	1.4752
	z	0.3457	2.0978	13.1208	69.2250	2.2006	13.0101
	θ_x	97.1943	1.1042	0.7900	0.0504	0.0504	0.8108
	θ_z	0.1531	7.7490	3.3256	7.1807	0.0154	81.5761
	θ_z	0.7694	84.2094	10.2737	1.3135	0.3135	3.1187

The above table shows that the natural frequency of the suspension before optimization is beyond the scope of the set, and there is a more serious coupling phenomenon is not conducive to the suspension damping control. Using GUI program shown in Figure3 to optimize the suspension, the modal energy of power plant optimized distribution percentages shown in Table 4:

Table 4 Modal Energy of power plant optimized distribution percentage

Natural frequency		17.0106	15.5010	9.9622	7.8326	7.2120	7.5175
Energy Amount of Hundred Branch Ratio	x	0.0003	0.0819	90.0231	9.7932	0.0975	0.0033
	y	0.0006	0.0055	0.0003	0.0536	0.0027	99.9372
	z	0.0275	0.0002	0.0059	1.4984	98.4612	0.0065
	θ_x	99.5603	0.4166	0.0004	0.0019	0.0311	0.0008
	θ_z	0.111	0.8217	9.6606	88.0765	1.4017	0.0438
	θ_z	0.4001	98.6741	0.3097	0.5764	0.0057	0.0083

From the above table it can be seen, the natural frequency and extent of decoupling of energy have reached the ideal level, That is essential to meet the preliminary design of power assembly mounting system designed by the design of the GUI program.

5. Conclusions

This thesis analyzed the mathematical model of six degrees of freedom for the four-point mounting system established. Contacted suspension system decoupled from energy and natural frequency of the structure and suspension parameters, the suspension optimized GUI program designed, the structure parameters of the suspension was optimized preliminarily, and achieved good results.

Acknowledgements

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