Experimental Research on Dynamic Characteristics of Primary Mirror of Vehicle Sights

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Abstract: The battlefield environment, external vibration load condition is complex, in the process of vehicle and shooting, random vibration and impact load can lead to car sight structure stress and strain of the primary mirror, will affect the performance of the vehicle sights. Aimed to study the vibration impact load of car mirror, the influence mechanism, the paper designed the experimental study of on-board sights that modal experiment, sine scanning, random vibration and impact. To improve the environment of on-board sight reliability and performance is of great significance.

1. Primary mirror experimental modal analysis

1.1 Vibration load conditions

A sinusoidal scanning mirror, random vibration and impact are provided by vibration table, can be adjusted through the shaking table controller excitation amplitude and frequency, vibration experiment is divided into sine scanning experiment, random vibration experiment and impact[1].

1.2 Laboratory equipment

The experimental modal analysis of the main equipment include: automotive sights primary mirror, piezoelectric acceleration sensor, data acquisition system and force hammer.

Experimental data acquisition system, can achieve 16 channels synchronous sampling, the highest use frequency of 256 kHz/channel. Experimental force hammer head material can be adjusted, covering different frequency width of pulse excitation, meet the requirement of different frequency response, and is suitable for small and medium-sized structure mode excitation.

1.3 Experiment method

The experimental analysis includes dynamometry and contingency force method. Of dynamometry according to different incentives divided into hammer excitation method and the vibrator excitation method, hammer excitation method is divided into SIMO, MISO and partitioning integrated mode, and vibrator excitation method is divided into SIMO and pure mode[23].

According to the input signal in a different way, the unexpected force method is usually divided into work incentives and environmental incentive method, experiment using hammer excitation incentives, simulation environment for high frequency response, select stainless steel hammer random excitation.

To obtain accurate experimental data. Experiment selected 28 points for the reference point, make the 7 batches, each batch use six sensors to collect 6 point signal, each batch sensor measuring point number as shown in table 1.

Tab. 1 Each batch sensor bonding point

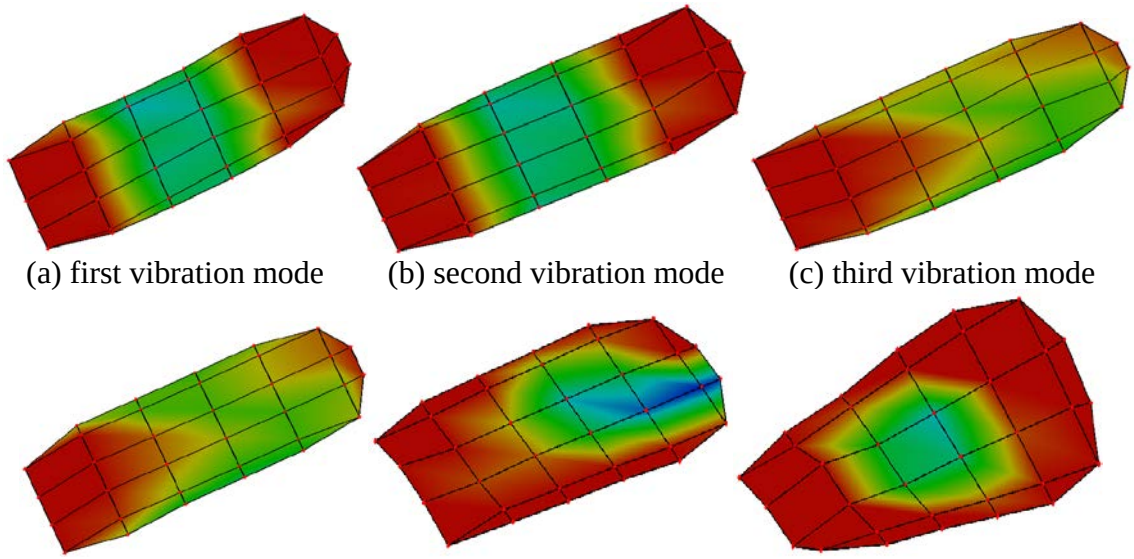
Batch	measuring point
1	1、2、3、4、5、28
2	6、7、8、9、10、28
3	11、12、13、14、15、28
4	16、17、18、19、20、28
5	21、22、23、24、25、28
6	26、27、29、30、31、28
7	32、33、34、28

1.4 Analysis of experimental results

Experimental modal analysis for the first six order natural frequency and damping as shown in table 2, the primary mirror before six order vibration mode is shown in figure 1.

Tab. 2 The first six natural frequency and damping of primary reflector

Step	1	2	3	4	5	6
Natural frequency (Hz)	166.016	249.023	710.449	825.195	1975.098	2121.582
Damping	0.012	0.008	0.008	0.005	0.109	0.006



(a) first vibration mode (b) second vibration mode (c) third vibration mode

(d) fourth vibration mode (e) fifth vibration mode (f) six mode vibration mode

Fig. 1 The first six vibration mode of primary reflector

From figure 3, the first and second order vibration mode of primary mirror deformation mainly occurred in the far distance trunnion two edges, perpendicular to the direction of vibration lens, third-order and fourth-order and five order vibration mode are mainly concentrated on the edge of the primary mirror of a, another edge deformation is reduced, and the six order vibration mode is the most serious, the primary mirror mirror distortion occurs, mirror around along three directions are large deformation occurred. Experimental modal analysis results and the simulation shows that the results of modal analysis and the inherent frequency error is less than 15%, in the range of allowable error, verify the rationality of the simulation analysis.

2. Sine scanning

2.1 The experiment system

Test equipment for the DS - 300-3-04 electric vibration test system, the test rig can quota and sweep frequency sine vibration test, mainly includes the vibration table, D - 300 S - 0404 horizontal sliding table, FJ - 200 fan, RC - 2000 digital vibration control instrument and SAI-3 power

amplifier[4].

2.2 The experimental steps

According to the size of the vibration table and the fixture, the mirror under test and the framework by four nut is fixed on the vibration table, according to the need in the corresponding parts of the vibration table and mirror surface-bonded piezoelectric sensors. Start the vibration device, and monitoring, obtain primary mirror sine scanning results, if there is any abnormal immediately halt[5].

2.3 Analysis of experimental results

The transfer characteristic curve shows that X direction sine scanning, there was a peak in the 151 Hz and 160 Hz, amplitude ratio were 11.6 and 72.7; Y direction when sinusoidal scanning, there was a peak in the 148.6 Hz, amplitude ratio 25.5; Scan the Z direction, Z direction sine scanning, there was a peak in the 157.97 Hz, amplitude ratio 1.23, there was a valley in the 168.5 Hz value, amplitude ratio 0.6. X, Y direction maximum acceleration amplitude magnification 10 or more, and the system structure design requirements there is a certain deviation, perhaps the main cause is the error of the experiment equipment installation as well as the framework make the stiffness of strength is not enough, the Z direction of the acceleration amplitude magnification is 1.23, meet the requirements of magnification is not more than 10. Peak frequency range between 148.6 Hz~168.5 Hz, and the analysis results of modal experiment 166.016 Hz between certain error, maximum error less than 10.5%, within the range of allowable error.

3. Random vibrations

3.1 Experiment system built

Random vibration test system mainly includes the electro-dynamic vibration system, data acquisition system, computer and sensor[6] etc.

3.2 The experimental process

Primary mirror lens upward horizontal fixed installed on the frame, random vibration experiments were set up five measuring point.

Carried out in accordance with the experimental load conditions in Z to random vibration experiment, the data acquisition instrument sharing five channels testing signals of different position, corresponding to the measuring point respectively CH1 and CH2 and CH3, CH4, CH5, including CH6 for input signal measuring point vibration table. The channel interface, the corresponding relationship between number of measuring points AI7-01 for CH1, AI7-02 for CH2, AI7-03 to CH3, AI7-04 as CH4, AI7-05 for CH5, AI7-06 CH6.

3.3 Analysis of experimental results

Random vibration experimental results as shown in table 3.

Tab. 3 Random vibration experimental results

measuring points	frequency response（Hz）	amplitude spectrum（g）	response power spectral density（g^2/Hz）	RMS spectrum peak	Magnification
CH1	604.248	65.165	695.737	46.622	14.416
CH2	604.248	74.893	839.245	53.594	22.575
CH3	604.248	59.857	587.023	42.812	13.124
CH4	604.248	141.267	3269.688	100.02	33.139
CH5	604.248	93.377	1428.567	66.814	19.963
CH6	604.248	13.869	31.513	9.94	—

Experiments were collected 6 random vibration response of the measuring point, among them 1~5 points in response to a point, 6 points for control signals. The random vibration analysis of experimental results shows that six test point response peak frequency of 604.248 Hz and 1885.986 Hz, maximum magnification of 33.139, compared with the previous four point anomalies, through analysis, on the one hand, the reason may be that the sensor paste were not strong enough or sensor sensitivity changes, on the other hand may be acquisition system channel signal transmission error occurs.

4. Conclusions

This chapter first sights in vehicle mirror as experimental object, design and build the interior vibration experiment system, mainly including the experimental modal analysis, sine scanning experiment, random vibration experiment and impact experiment, theoretical analysis and simulation results are verified.

In conclusion, through the vibration of the vehicle sights and temperature experiment research, the primary mirror in each car a sight under vibration loading stress, acceleration response and optical lens in uniform temperature field under the load of stress and strain regularity, for onboard photoelectric system structure design and material selection to provide the theoretical and experimental basis.

References

[1] Zhang Yongdong. A pickup white body modal experimental design [J]. Modern commercial and trade industry, 2015, 1:1.

[2] Cao Yang, li Yin. Motor frame of modal test and simulation [J]. Journal of design and research, 2015:7-10.

[3] Wei-jin ma, Zhang Lin, Ji-ping zhang, etc. Based on DASP gearbox shell vibration modal test and analysis [J]. Journal of mechanical transmission, 2015, 33 (3) 6:116-119.

[4] Zhang Yuli. Based on the sinusoidal scanning test simulation environment incentive mechanism of the equivalence of research [D]. Master degree theses of master of Harbin industrial university, 2014.

[5] Wang Xiaoyin ying-chun shan, xian-dong liu, et al. Sine sweep and random particle damper damping effect comparison [J]. Journal of noise and vibration control, 2014 (5) : 198-202.

[6] Miko. Airborne radar antenna array random vibration analysis and electromechanical integrated design [D]. Master degree theses of master of xian university of electronic science and technology, 2014.