The Auto Parts Road Simulation Vibration Test Platform Design

Tieyi Zhang[1,a], Shangxuan Gu[2,b*] and Zhenliang Huang[3,c]

[1]School of .Mechanical Engineering, Guangxi University, Nanning 530004, China

[2] Financial Office of Guangxi Transportation Department, Nanning 530012, China

[3] Science And Technology Department, Guangxi University, Nanning 530004, China

[a] zhangty-1@163.com, *Corresponding author: [b]gsx65@126.com, [c] hzlcgk@126.com

Keywords: Mechanical, Three freedom degrees, Vibration simulation test.

Abstract. According to the functional requirements of mechanical auto parts road simulation vibration test platform, mechanical auto parts road simulation vibration test platform structure is studied and designed, and a vibration simulation test platform entity is developed which can simulate auto parts vibration test on the actual road. The vibration simulation test platform design features is verified by experiments.

Introduction

Currently, there are mainly two types of auto parts simulation platform. One type is seismic simulation platform used traditional mechanical exciter. The traditional mechanical exciter has a disadvantage of that excitation frequency is single and amplitude adjustment is difficult, but has an advantage of low price, simple in structure and easy to use[1,2]. Another type is seismic simulation platform used electromagnetic and electro-hydraulic exciter. Electromagnetic seismic simulation platform can control vibration frequency freely, and waveform distortion is small. But it will be difficult for large displacement test, and large equipment is needed for large force. Electro-hydraulic exciter seismic simulation platform is ideal in performance as it is easy to implement low-frequency large displacement test, but not ideal as it has high cost, large auxiliary equipment and inconvenience in use. Based on the research of traditional mechanical exciter, a new mechanical auto parts road simulation vibration test platform is studied and designed by using a new mechanical exciter[3].

Mechanical Auto Parts Road Simulation Vibration Test Platform Functional Requirements

The features of the mechanical auto parts road simulation vibration test platform to be achieved are as follows: (1) Two-way and three degrees of freedom vibration function. It can realize vertical, horizontal and rocking vibration. (2) The continuous vibration amplitude adjustment and multi-frequency excitation output function. It can achieve 0-100mm continuous vibration amplitude adjustment and a combination output of multiple vibration frequencies.

Mechanical Auto Parts Road Simulation Vibration Test Platform Design

Mechanical auto parts road simulation vibration test platform is composed of vibration mechanism, the movement-guided and transmission mechanism, rack and vibration table board, control systems and other components. Vibration mechanism is a key component of the vibration simulation test platform, and the exciter performance determines the overall performance of the vibration simulation test platform. The traditional mechanical exciter has poor performance of single excitation frequency and difficult amplitude adjustment[4]. To improve the performance of mechanical auto parts road simulation vibration test platform, a new mechanical vibration exciter which uses a dual driven slider-crank vibration mechanism is applied in auto parts road simulation vibration test platform [5].

Published by Atlantis Press, Paris, France.

New Exciter Mechanism. Dual driven slider-crank mechanism of the vibration test platform exciter is shown in Fig.1. The two drive torques act on the links AB and CD. The rotational speeds ω1 and ω2 of this two links can be independently controlled. The movement of the slider D is the output of the exciter. Two optical encoders are connected to the mandrels of the hinge A and D respectively for measuring the angular displacements α1 and α2 of the links AB and CD. Composite frequency vibration output and the adjustment of the vibration frequency can be achieved by adjusting angular speeds ω1 and ω2 of the two links. And the vibration amplitude of the block D can be changed by controlling the phase difference between the α1 and α2.

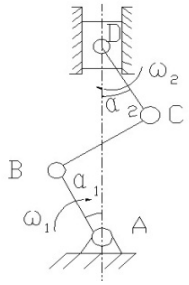

Figure 1 dual driven slider-crank mechanism exciter schematic

Vertical Vibration Output Shaft Guide Device. Vibration simulation test exciter output shaft rail is usually in the form of sleeve rail. Sleeve rail has a disadvantage of large friction and easy wear since that the exciter output shaft is sliding friction, and a disadvantage of high requirements of sleeve machining and assembly process. The friction is small when a hydrostatic bearing is used, but it is difficult to maintain and its cost is high. So we adopted roller guide form with using a circular output shaft instead of square output shaft to avoid over-positioning. The output shaft is clamped for guiding through three directions of the upper and lower layers of rollers. The guide means of vibrating output shaft is shown in Fig.2.

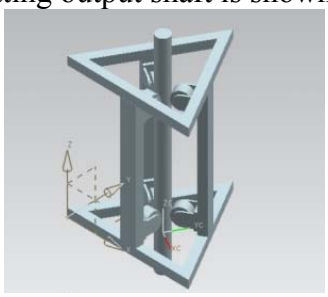

Fig. 2 The vibration output shaft guide device

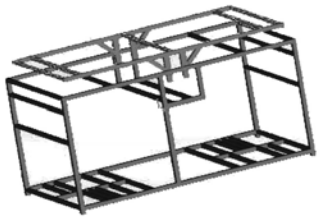

Fig.3 Rack and vibrating table board

Rack and Vibrating Table board. Auto parts road simulation vibration test rack is used for mounting motors and vibration mechanism, guided and connected institutions as well as detection devices. The vibration table board is used for mounting the auto parts. Rack and vibrating table board adopted steel welded frame structure to ensure strength, stiffness and stability, at same time to reduce the weight, as shown in Fig.3. The reduction of vibration board weight improves the load capacity of the vibration platform.

Vibration Test Platform Mechanical Structure Design. In order to achieve the horizontal and vertical vibration and swing, auto parts road simulation vibration test platform needs to install two vertical vibration exciters and a horizontal vibration exciter. In the overall layout, two vertical exciter output shafts are respectively arranged at two sides of the vibration test platform, and the horizontal exciter is arranged in the upper portion of the platform rack. For rational use of space, four drive motors of the two exciters are respectively arranged at the both sides of the vibrating table. Through the transmission mechanism the exciter drive motor torque are transmitted into the input shaft of exciter. The role of the transmission mechanism is to ensure that the maximum torque output frequency of the inverter is consistent with the center frequency of vibration platform excitation output.

Vibration Test Platform Control System. Auto parts road simulation vibration test platform control system hardware uses Panasonic PLC as the main control unit. Three-phase motor speeds are controlled by inverter. The motor rotation angular displacement signals are collected and

feedbacked to the PLC by optical encoders. The PLC using the encoder feedback signals to adjust and control the inverter constitutes a closed-loop control. According to the rotation angular displacement signal, the PLC calculates the motor speeds and the phase difference between the two motors, and then controls the inverters to change the motor speeds so that each motor speed and phase meet the exciter output requirements to form motion synthesis. Thereby the different amplitude of vibration can be obtained and stepless amplitude adjustment can be achieved.

Entities Production And Testing

According to the above design methods auto parts road simulation vibration test platform entity is developed as shown in Fig.4 with the dimensions of 1.6m long ,0.8m wide and 0.9m high. The maximum load is 200kg and the maximum displacements are ± 50 mm vertical and ± 25 mm horizontal. Fig.4 (a) is the panorama of mechanical auto parts road simulation vibration test platform. Fig.4(b) is dual driven slider-crank mechanism exciter and Fig.4(c) is the vibration output shaft guide device.

a) b) c)

Fig.4 Mechanical auto parts road simulation vibration test platform

A variety of vibration test has been carried out in order to test the performance of the auto parts road simulation vibration test platform. Different vibration amplitude, speed, acceleration output can be obtained through the different combination of speed and phase of two drive motors in an exciter of vibration test platform from the test result. Taking a single dual driven slider-crank exciter in vibration test platform as an example being excited in the test, setting two drive motor rotation directions to be the same and the two motors to be in the initial phase difference of 0 degree. Remains the frequency of the first motor f1 = 4Hz the same, changes only the second motor frequency f2. Let f2 = 4Hz, 8Hz and 12Hz respectively, The relationship that the vertical direction displacement of the vibration output shaft changes over time is obtained and shown in Fig.4. It is found that vibration displacement remains constant and the vibration displacement amplitude is 0 when f2 is the same as f1. This is a special case of the exciter output.

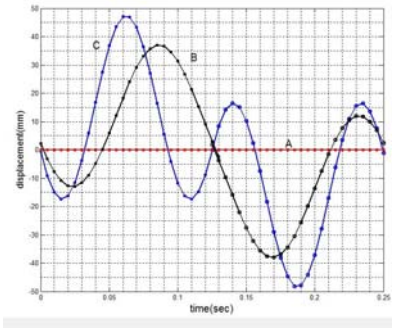

Fig.5 Unilateral dual driven slider-crank displacement in different frequency

A: f2=4Hz B:f2=8Hz C:f2=12Hz

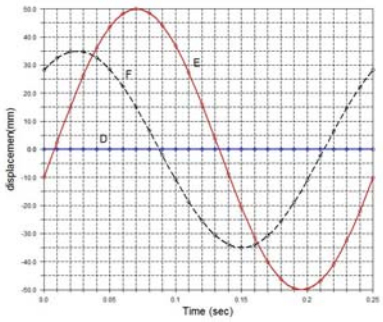

Fig.6 Unilateral dual driven slider-crank displacement in different phase difference

D: ⊿α=0° E: ⊿α=180° F: ⊿α=270°

Setting two drive motor frequencies remain the same, that is f1=f2=4Hz, and changing only the initial phase difference ⊿α from 0°to 360°, the relationship that the vertical direction displacement of the vibration output shaft changes over time is obtained and shown in Fig.6. It is found that the vibration displacement amplitude is 0, 50mm and 35mm respectively when the initial phase

difference $\angle\alpha$ is 0, 180°and 270°. The vibration displacement amplitude changes from 0 to 50mm when phase difference changes from 0 to 360°.

Conclusion

New mechanical auto parts road simulation vibration test platform is a mechatronic vibration test platform. Through the integrated use of a variety of mechanical and electrical control technology it has been achieved that the mechanical exciter amplitude adjusts continuously and a combination of multiple vibration frequencies output. It improves vibration performance and meets the different needs of the excitation amplitude and frequency. It is a new kind of auto parts road simulation vibration test platform, compared with electromagnetic and electro-hydraulic exciter vibration simulation test platform, low cost, easy to use, has good application prospects.

Acknowledgement

The research is supported by the Guangxi Natural Science Foundation for Young Scholars (No.2010GXNSFB013005 and No.2011GXNSFB018015) and Guangxi Key Laboratory of Manufacturing System & Advanced Manufacturing Technology. And Shangxuan Gu is the corresponding author (e-mail: gsx65@126.com).

References

[1] Liao Shijia, Wu Yan, Wang Dedong. Pneumatic Vibration Desk Performance Comparison Simulation Study [J]. Mechanical Science and Technology, 2008,27 (6) :16-20.
[2] Jing Zhenlin,Gao Feng. Three Degrees of Freedom of A Mechanical Vibration Test Platform. China Patent No.: CN 1614376A.
[3] Wang Kao. Pneumatic Vibration Table Vibration Excitation Spectroscopy Optimization Study[D]. National Defense Science and Technology University Doctoral Dissertation 2009.5.
[4] Ali Kirecci, L. Canan Dulger. A Study on A Hybrid Actuator, Mechanism Machine Theory. 2000, 35 (2) :1141-1149.
[5] Li Xuegang, Feng Liyan. Hybrid Drive Controlled Institutions of The Status Quo And Development Trend [J]. Hebei Institute of Technology, 2004, 26 (3) :13-17.