Advanced Management Science (AMS)

DOI: *http://doi.org/10.7508/ams.01.2024.18.21*

ISSN: 2222-4955 (Print)
ISSN: 2222-4963 (Online)
CODEN: AMSDFK

ARTICLE

CURRENT SITUATION ANALYSIS OF VIBRATION ISOLATOR

Yuhao Cui[1], Fuxi Liu[1], Jiaqi Li[1], Xiang Liu[2*], Jianwei Zeng[1], Jinchao Chen[1], Yuyang Li[1], Wenjie Qi[1]

[1]School of Mechanical and Electrical Engineering, Hunan Applied Technology University, Changde 415100, China
[2]Party and Government Office, Hunan Applied Technology University, Changde 415100, China
[*]Corresponding Author Email: 1751611391@qq.com

ARTICLE DETAILS

Article History:

Received 12 January 2024
Accepted 7 March 2024
Available online 20 March 2024

ABSTRACT

The vibration is ubiquitous in the engineering practice and human living environment. Vibration isolator could be used to reduce the vibration. Vibration isolator mainly include the spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator, quasi zero stiffness isolator and so on. The aim of this paper is to analyze the current situation of the spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator and quasi zero stiffness isolator.

KEYWORDS

Vibration Isolator; Spring Isolator; Rubber Isolator; Wire Rope Isolator; Magnetic Levitation Isolator; Magnetorheological Isolator; Quasi Zero Stiffness Isolator

1. INTRODUCTION

The vibration is ubiquitous in the engineering practice and human living environment [1]. The vibration includes harmful vibration and favorable vibration. The harmful vibration can destroy the object, affect the safety of major projects, and harm the health of people. Therefore, the vibration reduction is an urgent problem that needs to be solved. Simply put, the vibration reduction are the measures to reduce the system vibration such as reduce the incentive, increase the system damping, set the shock absorber, vibration isolation, vibration attenuation and so on. In recent years, more and more researchers begins to pay attention to the vibration isolation technology. In the field of vibration isolation, spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator and quasi zero stiffness isolator are widely used. Based on this, this paper anylyze the current situation of spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator and quasi zero stiffness isolator.

2. SPRING ISOLATOR

Yu et al. [2] analyzed the vibration isolation effect of steam turbine generator set after installing the spring isolator. It was found that the foundation plate vibration of steam turbine generator set after installing the spring isolator was obviously reduced.

Jin et al. [3] established the mechanical model of bag-type molecular spring vibration isolator and analyzed the mechanical performance of bag-type molecular spring vibration isolator. They found that the bag-type molecular spring vibration isolator exhibited segmental stiffness characteristics of high, low and high.

Take for example the installment of the first 1350 MW turbine generator base vibration isolation spring, Wang et al. [4] pointed out the key points and matters needing attention of the spring isolator installation supervision during ultra large capacity turbine generator base construction.

The molecular spring isolator was a new type of isolator which used the water and hydrophobic zeolite particles as the working medium. The molecular spring isolator had segmental stiffness characteristics. Yu et al. [5] established the mechanical model of molecular spring stiffness and analyzed the vibration isolation performance of molecular spring which used the energy transfer rate as the evaluating indicator. It was shown that the vibration isolation performance of the molecular spring isolator was better than that of the traditional linear isolator.

The stiffness and damping of steel spring isolator were the important parameters which affected the damping performance of the floating slab track structure. In order to clarify the mechanical characteristics of steel spring isolator, He et al. [6] conducted the experimental research for the steel spring isolator.

Based on the indoor testing of floating plate track steel spring isolator, Wang et al. [7] investigated the frequency dependence and amplitude dependence of the stiffness and damping of floating plate track steel spring isolator.

Aiming at the model uncertainty problem of air spring active isolation system, Zhou et al. [8] deesigned the controller of air spring active isolation system and found that the robust controller could enable the the system to still maintain the stability and was still able to improve the passive isolation characteristics compared to the conventional PID controller.

3. RUBBER ISOLATOR

In order to explore the characteristics of generalization, serialization and combination design of assembled rubber isolator, Lou et al. [9] developed a combination of finite element simulation and testing to investigate the static characteristic of assembled rubber isolator. It was shown that the assembly direction of isolation ring had a significant impact on the shape and static characteristic of assembled rubber isolator. It was also shown that the proposed method had high accuracy and feasibility and could provide the theoretical guidance for the application of assembled rubber isolator technology.

In order to reflect the amplitude and frequency correlation of the dynamic characteristics of hydraulic damping rubber isolator, Liu et al. [10] established a new nonlinear model.

To the fatigue performance problem of rubber vibration isolator, the impact of forming method was easy to be neglected. Peng et al. [11] investigated the impact of forming method on the fatigue performance problem of rubber vibration isolator.

Aiming at the high requirement for the vibration isolation performance of sophisticated electronics, Yu et al. [12] investigated and designed a nonlinear isolator with double-layer metal rubber.

Zhang et al. [13] designed a composite rubber isolator. This composite rubber isolator could effectively control the high-frequency vibration.

By analyzing the impact excitation on ground foundation before installing the rubber isolator to the eccentric press and after installing the rubber isolator to the eccentric press, Huang et al. [14] obtained the vibration isolation effect of rubber spring.

Hang et al. [15] measured the dynamic stiffness and damping ratio of the main vibration direction of the isolator system in high and low temperature environments and analyzed the relative error caused by approximate formulas which calculated the dynamic stiffness and damping ratio.

4. WIRE ROPE ISOLATOR

Wang et al. [16] investigated the parameter identification method of hysteresis model. It was shown that the proposed method could accurately identify the parameters of hysteresis model.

The wire line ring was the key vibration isolation element for the O-shape wire line vibration isolator. Wang et al. [17] investigated the parameter design of O-shape wire line vibration isolator ring based on the Matlab software.

Tian et al. [18] investigated the impact resistance of wire line vibration isolator for different structural parameters. It was shown that the effect of section diameter on the equivalent impact stiffness was most significant and the effect of spiral diameter on the impact loss factor was most significant.

Aiming at the disadvantage of poor tensile performance of traditional wire line vibration isolator, Zhang et al. [19] designed a new type of bidirectional compressible wire line vibration isolator.

In order to investigate the mechanical property of spherical wire line vibration isolator, Lu et al. [20] proposed a new modeling and simulation method.

Wang et al. [21] investigated the modeling and parameter identification of the dynamic hysteresis characteristics of wire line vibration isolator. It was shown that the established model could better describe the dynamic hysteresis characteristics of wire line vibration isolator and the employed parameter identification method could accurately and effectively identify the model parameters.

5. MAGNETIC LEVITATION ISOLATOR

Wang et al. [22] investigated the effect of sliding mode control on the vibration isolation characteristics of magnetic levitation isolator. They found that the sliding control algorithm could significantly decrease the dynamic reaction force and vibration intensity of framework in the full frequency domain range and reduce the transmission rate of vibration isolation system.

Li [23] designed one kind of magnetic levitation isolator. It was shown that there was obvious vibration isolation effect for this kind of magnetic levitation isolator.

Aiming at the low accuracy and narrow frequency band of semi-active isolator, Zhu et al. [24] designed one kind of magnetic levitation isolator structure which was composed of permanent magnets and electromagnets. It was shown that there was better vibration isolation effect for the designed hybrid magnetic levitation isolator.

Wu et al. [25] established the nonlinear dynamic model of magnetic levitation isolator for the control design and analyzed the dynamic response of magnetic levitation isolator for different excitation disturbances.

Song et al. [26] proposed one kind of model identification method based on the improved BP neural network and established the model of magnetic levitation isolator. It was shown that the established model had higher accuracy and could meet the didentification requirement of dynamic electromagnetic force model of magnetic levitation isolator.

6. MAGNETORHEOLOGICAL ISOLATOR

In order to effectively reduce the multi directional and broadband vibration transmitted from the helicopter rotor to the fuselage, Wang et al. [27] proposed a new type of helicopter main magneto rheological isolation system based on the full coefficient adaptive control. It was shown that the full coefficient adaptive controller based on the feature model had better vibration isolation effect compared to the passive vibration isolation.

Due to the high power consumption and low magnetic stiffness of magnetorheological elastomer vibration isolator, Fan et al. [28] performed the multi-objective optimization design for the shear and compression magnetorheological elastomers and related structural parameters which used the low power consumption and high magnetic stiffness as the optimization objective.

Ma et al. [29] tested the frequency shift characteristics of magnetorheological elastomer vibration isolator based on the experiment on the sweepfrequency excitation. They found that the magnetorheological elastomer vibration isolator had wider frequency shift range.

Song et al. [30] performed the analysis and simulation for the vibration isolation system of magnetorheological vibration isolator based on the Abaqus software.

Li et al. [31] proposed the optimization method for the vibration isolator winding area structure.

7. QUASI ZERO STIFFNESS ISOLATOR

Deng et al. [32] proposed one kind of biomimetic quasi zero stiffness isolation device and established its nonlinear dynamical model.

Based on the positive and negative stiffness parallel connection, Chai et al. [33] proposed one kind of electromagnetic quasi zero stiffness isolator.

Aiming at the problem which the existing quasi zero stiffness torsional isolator applied only to the constant load, Zhang et al. [34] designed a new type of quasi zero stiffness torsional isolator which adjusted the positive stiffness to adapt to the change of load and adjusted the negative stiffness to ensure the isolator to always operate in the quasi zero stiffness state.

Aiming at the problem of insufficient low-frequency vibration isolation performance of traditional passive isolator, Yang et al. [35] proposed a new type of quasi zero stiffness isolator.

Han et al. [36] proposed a nonlinear weakening method for the quasi zero stiffness isolator which utilized the gradually softening negative stiffness to neutralize the gradually hardening negative stiffness.

Wang et al. [37] the parallel and serial inerter-based quasi zero stiffness isolators according to the layout form of inerter-based, spring and damper.

8. CONCLUSIONS

The vibration includes harmful vibration and favorable vibration. The harmful vibration can destroy the object, affect the safety of major projects, and harm the health of people. Vibration isolator can be used to reduce the harmful vibration. Vibration isolator mainly includes the spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator, quasi zero stiffness isolator and so on. Although many researchers have investigated the spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator and quasi zero stiffness isolator, there are still many problems to study for the spring isolator, rubber isolator, wire rope isolator, magnetic levitation isolator, magnetorheological isolator and quasi zero stiffness isolator.

ACKNOWLEDGEMENTS

This study was supported by the National College Students' Innovative Entrepreneurial Training Plan Program (Grant No. S202313809023) and Hunan Province College Students' Innovative Entrepreneurial Training Plan Program (Grant No. S202313809024).

REFERENCES

[1] Hao, Z. Research on dynamics and vibration control based upon high-performance low-frequency isolation. Harbin Institute of Technology Doctoral Dissertation, 2016.

[2] Yu, L., Fan, L., Sun, M. Vibration damping performance analysis and experimental study of steam turbine genrator based on spring vibration isolator. Explosion-Proof Electric Machine, 2023, 58(6): 27-30.

[3] Jin, Y., Chen, W., Chen, Q., Teng, H. Analysis of mechanical properties of bag-type molecular spring vibration isolator. Journal of Vibration, Measurement and Diagnosis, 2023, 43(2): 240-245, 406.

[4] Wang, Z., Gao, M. Quality control of spring isolator installation based on process supervision. Electric Engineering, 2022, (14): 172-174.

[5] Yu, M., Gao, X., Chen, Q. Dynamic properties of molecular spring isolator. Journal of Vibration Engineering, 2016, 29(5): 913-919.

[6] He, Q., Zhu, S., Chai, C., Zhang, J. Experimental study on mechanical characteristics of the subway-using steel spring vibration isolator. Journal of Railway Science and Engineering, 2016, 13(8): 1492-1498.

[7] Wang, J., Cai, C., Zhu, S. Experimental study on frequency and amplitude dependent behavior of dynamic parameters of steel-spring vibration isolator used in floating slab track. Scientia Sinica: Technologica, 2016, 46(8): 808-814.

[8] Zhou, Y., Wang, X., Zheng, G. Study on robust control of an air spring active vibration isolator. Journal of Vibration and Shock, 2007, (1): 125-129, 166.

[9] Lou, J., Yang, Q., Chai, K., Zhou, C. Research on model modification and static characteristics of assembled rubber isolator. Ship Science and Technology, 2023, 45(21): 44-49.

[10] Liu, X., Han, Y., Jiang, J., Zheng, Y., Yin, Z., Shangguan, W. Modeling method for dynamic characteristics of hydraulic damping rubber isolator. Journal of Vibration and Shock, 2023, 42(17): 160-165, 264.

[11] Peng, Y., Yang, J., Pan, G., Wang, Z. Influence of molding method on fatigue performance of rubber vibration isolator. Noise and Vibration Control, 2022, 42(6): 263-266.

[12] Yu, H., Zhang, S. Theoretical analysis and vibration isolation performance study of double-layer metal rubber isolators. Noise and Vibration Control, 2021, 41(5): 247-250.

[13] Zhang, X., Du, K. Characteristic analysis and design validation of compound rubber vibration isolator. Chinese Journal of Ship Research, 2020, 15(6): 149-154.

[14] Huang, X., Wang, H., Gu, L. Rubber isolator and its application in eccentric press. Machine Tool and Hydraulics, 2018, 46(8): 19-21, 33.

[15] Hang, C., Fan, Y., Su, E., Yan, Q. Research on dynamic character of rubber vibration isolator within different temperature range. Science Technology and Engineering, 2017, 17(2): 135-139.

[16] Wang, D., Meng, X., Yan, M., Kong, X. Mathematical modeling and parameter identification of wire rope vibration isolator. Machinery Design and Manufacture, 2023, (9): 125-127, 132.

[17] Wang, H., Ji, Y., Long, Y., Gong, Q., Zhang, W. Parametric design of O-typed wire-rope vibration isolator's wire-rope ring based on MATLAB. Journal of Mechine Design, 2022, 39(5): 109-115.

[18] Tian, H., Shan, G., Yan, M., Kong, X. Study on the shock resistance characteristics of wire rope isolator with different structure parameters. Journal of Vibration, Measurement and Diagnosis, 2022, 42(1): 117-123, 198-199.

[19] Zhang, C., Lu, K., Zhang, L., Yan, M., Zhang, Y. An experimental and simulation study on mechanical properties of new wire rope isolator. Journal of Vibration and Shock, 2021, 40(16): 213-219.

[20] Lu, K., Zhang, C., Zhang, L., Zhang, M., Yan, M. Numerical simulation method study on spherical wire rope isolator. Ship Science and Technology, 2021, 43(6): 74-78.

[21] Wang, H., Chen, D., Ji, Y. Research on dynamic hysteresis modeling and parameter identification of a wire-cable vibration isolator. Mechanical Science and Technology, 2020, 39(11): 1713-1719.

[22] Wang, H., Yan, B., Song, S., Huang, Y. Study on vibration isolation characteristics of sliding mode control in magnetic levitation isolator. Machinery Design and Manufacture, 2023, (7): 151-154, 159.

[23] Li, H. Research on vibration isolation characteristics of magnetically levitated vibration isolation system. Heavy Machinery, 2019, (4): 42-46.

[24] Zhu, W., Wang, C., Xu, Z., Chen, N. Research on structure design and control algorithm of maglev precise isolator. Mechanical Science and Technology, 2018, 37(3): 443-450.

[25] Wu, Q., Chen, S., Chen, Y., Yue, H., Liu, R. Nonlinear dynamics modeling and simulation of maglev vibration isolation system. Journal of Vibration and Shock, 2015, 34(20): 161-166.

[26] Song, C., Zhang, J., Zhang, J. Dynamic modeling of MSI based on a hydrid approach and experimental verification. China Mechanical Engineering, 2014, 25(14): 1929-1934.

[27] Wang, Y., Zhou, J., Cao, X., Xu, Y. Adaptive control of magnetorheological vibration isolation systems of helicopter main reducers. Noise and Vibration Control, 2024, 44(1): 96-103, 254.

[28] Fan, W., Meng, J., Du, Y., Liu, K., Jiang, T. Multi-objective optimization design of hybrid magnetorheological elastomer vibration isolator. Science Technology and Engineering, 2021, 21(30): 12866-12871.

[29] Ma, W., Huang, X., Wang, H., Zhang, G., Wang, J. Vibration isolation control and an experimental study of magnetorheological elastomer isolators. Journal of Vibration and Shock, 2020, 39(8): 118-122.

[30] Song, D., Ji, H. Design of magnetorheological isolator for ship vibration isolation system. Ship Science and Technology, 2019, 41(11A): 22-24.

[31] Li, R., Sun, T., Mu, W., Wang, X. The optimal design of track magneto-rheological vibration isolator and performance testing. Scientia Sinica Technologica, 2017, 47(4): 394-401.

[32] Deng, H., Chen, X., Wang, H., Zhang, F. Analysis and experiment of characteristics of quasi zero stiffness biomimetic isolation device base

on human foot arches. Journal of Vibration, Measurement and Diagnosis, 2024, 44(1), 129-134: 202.

[33] Chai, K., Hu, J., Wei, Y., Liu, S. Design and test of electromagnetic quasi-zero stiffness isolator. Ship Engineering, 2023, 45(11): 62-68.

[34] Zhang, C., Li, X., Zhang, S., Xu, D. Design and analysis of quasi-zero stiffness torsional vibration isolator adapting to load changes. Journal of Vibration and Shock, 2022, 41(23): 307-314.

[35] Yang, Y., Huang, L., Zeng, P., Liu, B. Design and dynamic research of a new quasi-zero stiffness vibration isolator. Chinese Journal of Applied Mechanics, 2023, 40(5): 1043-1049.

[36] Han, C., Liu, G., Shao, X., Liu, T., Xu, D., Zhang, K., Liu, X. Research on nonlinearity weakening method of quasi-zerostiffness vibration isolator. Nuclear Power Engineering, 2022, 43(S1): 121-126.

[37] Wang, Y., Li, H., Cheng, C., Ding, H., Chen, L. Dynamic characteristics of inerter-based quasi-zero stiffness vibration isolator. Journal of Vibration, Measurement and Diagnosis, 2021, 41(6): 1124-1131, 1237.