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Dynamic characteristics of the vibratory roller test-bed vibration isolation system: Simulation and experiment

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Abstract

The vibration test of the vibratory roller is of significant value before delivery and it is mainly done in outdoor test base at present. This method has low efficiency, poor security and reliability, so this paper proposes a new type of test-bed to regulate the commission test of the vibratory roller. This thesis regards the single-drum vibratory roller as a research object, and completes the overall structural design of the test-bed and theoretical analysis. The dynamic characteristics of vibration isolation system of the test-bed are studied by using theoretical analysis, experimental research and simulation analysis methods. According to the working principle of vibration isolation system of the test-bed, the dynamics model of vibration isolation system is established by using two-stage and inclined vibration isolation technology. The vibration isolation system is studied by using rigid-flexible coupling simulation method. Finally, based on the experimental optimization results of vibration isolation system, the test-bed is developed and its function is verified.

Keywords: Vibratory roller test-bed; Vibration isolation system; Two-stage vibration isolation; Rigid-flexible coupling simulation

1. Introduction

The vibratory roller is the major construction machine of construction project on roads, railways and airports. The requirements of its performance and quality are increasingly growing. It makes test performance of the vibratory roller become an indispensable link of its production process, because manufacturers are supposed to test their products. At present manufacturers mainly test the vibratory roller in test site named rubber tank. It has been proved that such methods have low efficiency, poor security or reliability, and the vibration noise has a great impact on the surrounding environment, therefore in order to improve the vibratory test property of the vibratory roller, this paper proposes a novel vibratory roller test-bed. The vibratory roller test-bed is a test equipment that simulates actual driving and vibration conditions in experimental base. The main functions of the test-bed are to realize run-in tests, load tests and vibratory property tests of the vibratory roller, including two working conditions (low-frequency high-amplitude and high-frequency low-amplitude). In other words, the roller tests are completed just in the test-bed. Vibratory parameters (including drum acceleration, frequency, frame acceleration, frequency, and amplitude uniformity) of the vibratory roller can be measured in the test-bed. The vibratory roller can be assessed by analyzing the test results. Finally inside systems of the vibratory roller are run-into ensure reliable operation.

The vibratory property test of the vibratory roller is done directly on the test-bed. The huge excitation force drives the test-bed, resulting in test-bed generating severe vibrating. This requires the roller test-bed having good damping and isolation capabilities. Therefore, it is

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Notation

The following symbols are used in this paper:

m_1	mass of test-bed	k_3	total stiffness of drum-frame
m_2	mass of drum	c_1	damping of rubber damping block
m_3	mass of frame	c_2	vertical damping of rubber inflatable tire
x_1	displacement of test-bed	c_2'	damping coefficient of rubber inflatable tire
x_2	displacement of drum	c_3	damping of drum
x_3	displacement of frame	F	excitation force of roller
k_1	total stiffness of rubber damping block	F_0	excitation force amplitude of roller
k_2	vertical stiffness of rubber inflatable tire	F_2	transmitting force
k_2'	total stiffness of rubber inflatable tire	F_A	transmitting force amplitude

necessary to make in-depth research on the dynamic property of the vibratory roller test-bed to improve its quality and property.

2. Dynamics property analysis of vibration isolation system of the test-bed

2.1. Development of vibration isolation system

The concept of vibration isolation system is early proposed by Schultz [1]. He published a article named "design and advantage of a two-stage mounting system for major machine in ship's engine room", which successfully advanced ship's engine noise attenuation of about 20 dB. In the 1970s, vibration isolation technology was applied to nuclear-powered submarine in former Soviet Union [2] Yan et al. [3] clarified the coupling characteristics of the double vibration isolation system and proposed approach of decoupling and experimental validation using model. Song et al. [4] researched the effects of double vibration isolation system design parameters on the performance of vibration isolation system, calculated the force transmission rate, and came to conclusion: with the mass ratio increasing, the force transmission rate is increasing; with the damping ratio increasing, the force transmission rate is decreasing; with the natural frequency increasing, the frequency band decreasing, the effect of vibration isolation is reducing [5–8]. Hu et al. [9] studied kinetic characteristics of double isolation system of diesel generator through theoretical analysis and experiment, the results showed that: reducing the upper isolator stiffness, increasing isolator stiffness was useful to improve the isolation effect [10]. Duan et al. [11] evaluated the isolation effect of double vibration isolation system by test method, and analyzed the relationship between isolation index and system parameters [12].

2.2. Dynamics analysis of vibration isolation system

This paper has designed a roller test-bed based on the requirement and function of the vibratory roller. The test-bed is mainly composed of a front vibration table, a rear rotary table, a mast, a bracket, and other auxiliary devices. The structure is shown in Fig. 1.

According to the principle and form of vibration isolation, vibration isolation system of the roller test-bed employs two-stage vibration isolation technology. The rubber tire device is the first-order isolator, and the rubber damping device is the second-order isolator. The supporting bench is the middle mass, and the whole device of two-stage vibration isolation system is connected to the base ground. According to the above assumptions, we

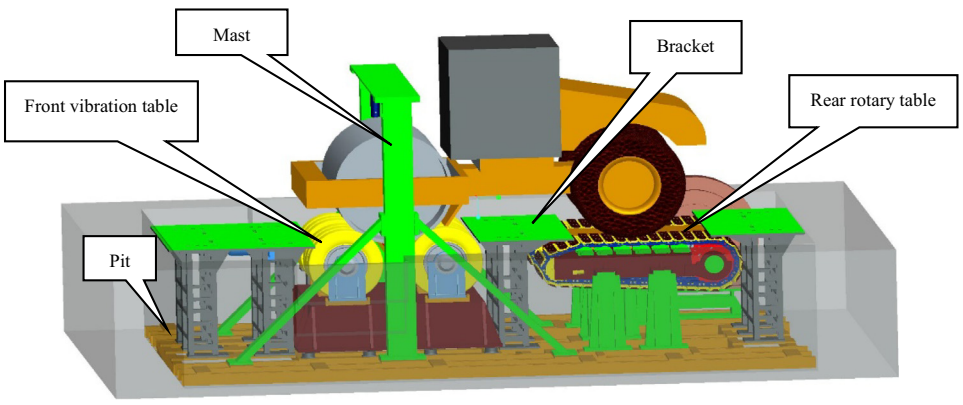

Fig. 1. The overall structure of the test-bed.