Vibration Analysis of the Support Structure of the Raw Material Banana Sieve

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Abstract

A three-dimensional finite element model of a coupling system consisting of a raw material banana screen frame and equipment in an alumina refinery was established using the finite element method. Natural vibration characteristics of the plant structure and resonance re-examination were analysed. By adjusting the stiffness of the plant building, the loading weight of the banana screen, and the natural vibration frequency of the system, based on simulation calculations of the plant floor and measured dynamic responses, this study investigated the changes in the natural vibration frequency of the raw material banana screen and the corresponding stiffness requirements of the plant building after implementing spring and damping shock absorbers for vibration reduction. The results indicate that the use of spring and damping shock absorbers has significantly reduced the overall vibration frequency of the banana screen; however, floor vibrations within the resonance zone remain pronounced. In practical applications, it is recommended to increase the stiffness of the plant building to prevent resonance. These findings provide a solid foundation for the anti-vibration design of plant structures in the raw bauxite slurry grinding step of alumina production.

Keywords: Raw material banana screen, Natural vibration characteristics, Dynamic response.

1. Introduction

Ball mills and banana screens are both heavy-mass, high-frequency vibration equipment commonly used in the raw bauxite slurry grinding process of alumina refineries. During operation, they generate significant vibration and noises, which may pose structural safety issues and varying degrees of noise pollution, potentially endangering the physical and mental health of personnel [1, 2] and causing substantial economic losses. Therefore, strict vibration design standards are applied in the raw bauxite slurry grinding process. Since ball mills are placed directly on the foundation, vibration amplitude and the structural vibration response of the main building can be reduced through foundation treatment, adding base counterweights of equipment, separating the equipment foundation from the main building structure, and implementing vibration mitigation measures [3, 4]. However, due to process requirements, banana screens are often installed at elevated positions, and their operation areas frequently serve as key zones of personnel activity. Hence, investigating the causes of banana screen frame vibrations and exploring effective vibration mitigation methods are important topics that warrant thorough academic attention.

Taking the frame of a specific banana screen as a case study, this paper analyses the vibration reduction effects of dampers on the raw material banana screen and the structural response patterns to different vibration frequencies. Based on actual dynamic response measurements of the equipment floor slab, supplemented by software simulations, it provides a reference for anti-vibration design of banana screen frames.

2. Computational Model and Working Conditions

2.1 Computational Model

Based on an engineering example, a three-dimensional finite element model of the equipment floor of the banana screen frame was created according to actual dimensions. During the model establishment process, the floor slabs and shear walls were modelled using shell elements, the beams beneath the equipment floor and the frame columns were modelled using frame elements, and the banana screen was represented by mass sources applied at the centre of mass of the equipment, based on its normal operating weight. The bottom nodes of the frame columns and shear walls were fully fixed. The finite element model of the banana screen frame concrete structure is illustrated in Figure 1.

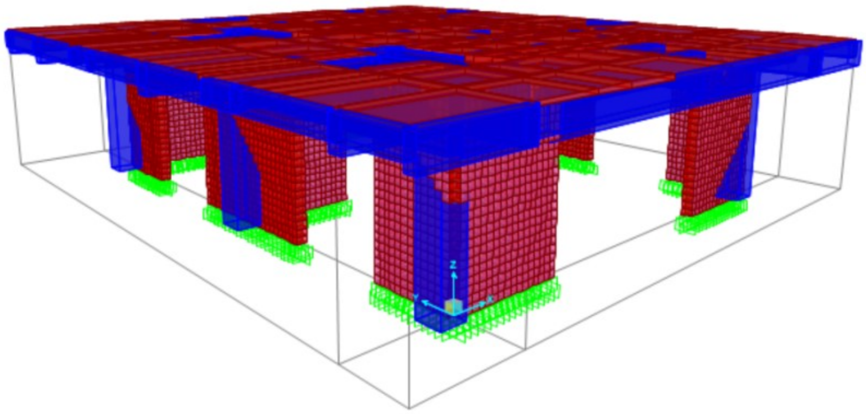

Figure 1. Finite element model of the banana screen frame concrete structure.

2.2 Working Conditions

The vibration characteristics of the banana screen frame were studied from the following aspects: (1) the vibration response behaviour of the equipment floor under varying operational frequencies of the banana screen; (2) the impact of vibration coupling and increased load when multiple banana screens are operated simultaneously, particularly in terms of vibration transmission; and (3) the influence of different loading quantities on vibration performance when the equipment operates at the same frequency. Detailed working conditions are presented in Table 1. The five working conditions listed correspond to different equipment and loading quantities, and include the natural vibration frequency of the banana screen during normal operation (15.6 Hz), as well as four reduced frequencies (14.66 Hz, 13.73 Hz, 12.2 Hz, and 11.5 Hz).

Table 1. Working conditions.

Nb of Operating Units	Loading quantities	Working Conditions
2	Normal	Conditions 1 to 5
	Full	Conditions 6 to 10
1	Full	Conditions 11 to 15

3. Natural Frequency and Resonance Re-examination of the Banana Screen Frame

First, the self-vibration characteristics of the banana screen frame structure were analysed using the modal analysis method to calculate the first 10 natural frequencies of the model. The first 20 natural frequencies are presented in Table 2. Specifically, the 10th mode corresponds to the

4.3 The Influence of Number of Operating Units

It can be inferred from the analysis of the vertical vibration velocity results at measurement point 1 that, when varying quantities of banana screen operate under normal conditions at different frequencies, the following observations can be made:

When a single banana screen is operating under normal conditions, the resonance frequency at measurement point 1 is higher than when two banana screens are operating simultaneously (as illustrated in Figure 5). Additionally, the vertical structural response within the resonant frequency range is greater compared to the case where both machines are operating normally. However, in the non-resonant frequency range, the structural response is reduced due to the lower vibration mass and energy, with the response of a single machine accounting for only 25–40 % of that observed when both machines are in operation.

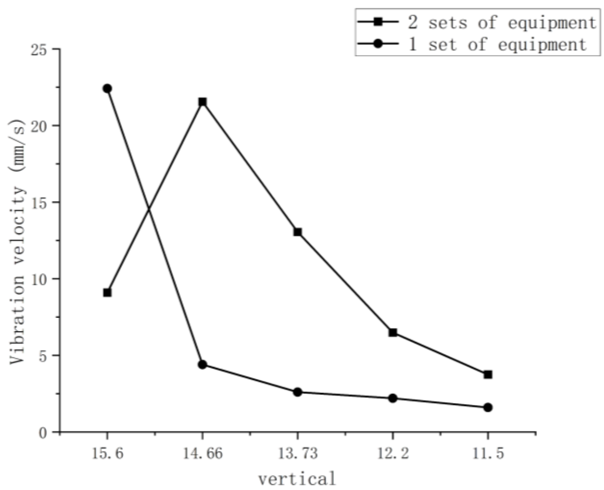

Figure 5. Vertical vibration velocity at measurement point 1 under different frequencies with different number of screens operating normally.

5. Conclusions

(1) The frame structure of the banana screen demonstrates a predominant vertical vibration response under the operational load of the equipment, while longitudinal and lateral vibration responses remain relatively minor, with the horizontal vibration response amounting to approximately 30 % of the vertical vibration response.

(2) Spring shock absorbers and damping shock absorbers can reduce the vibration frequency of banana screening equipment by approximately 25 %.

(3) When the banana screen and its supporting frame resonate, the vibration response of the structure can become significantly amplified. Prolonged resonance may compromise the safety and well-being of on-site personnel. In practical design, it is essential to enhance the rigidity of the main structure and regulate the natural vibration frequencies of structural components to ensure they remain above the resonance range of the banana screen equipment.

6. References

1. *Standard for Design of Dynamic Machine Foundations* – GB 50040-2020 (in Chinese).

2. *Standard for Vibration Control Design of Industrial Buildings* – GB 50190-2020 (in Chinese).
3. *Code for Calculation and Vibration Isolation Design of Bearing Structures of Buildings under Mechanical Dynamic Load* – YBJ 55-90 (in Chinese).
4. *Code for Design of Vibration Isolation* – GB 50463-2008 (in Chinese).
5. *Standard for Allowable Vibration in Building Engineering* – GB 50868-2013 (in Chinese).