Research on Key Technologies of Powdery Material Dynamic Buoyancy Weighing System Based on Comparative Compensation Method

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Abstract. Dynamic weighing device is widely used in material processing and manufacturing engineering. In the weighing process, due to the viscosity of special powder material, it will produce vibration and be affected by vibration acceleration when adding weighing hopper. Its weighing reading will fluctuate, thus can not accurately carry out dynamic weighing. On the basis of dynamic buoyancy weighing system, the weight sensor and compensation sensor are added to construct the mass spring damping system. Through the analysis of transfer function, it satisfies the condition of using comparative compensation method and can be realized in the same vibration environment. Real-time tracking and compensation of low-frequency random vibration from outside the system (buoyancy) can be performed. In order to greatly improve the weighing accuracy of low frequency random vibration. The experimental results show that the dynamic measurement accuracy of the dynamic buoyancy weighing system can be less than ±0.5% after the comparison and compensation of the dynamic buoyancy weighing system, which can basically meet the weight measurement of powder material.

1. Foreword
Dynamic weighing device is widely used in materials processing and manufacturing engineering. Measuring the level of development is one of the important symbols of the core competitiveness of the country. Dynamic measurement is a special measurement process, which refers to the continuous measurement process in which the measurement object system is in a moving state and is measured as a variable[7]. Dynamic measurement, especially the dynamic quantitative measurement of toxic and harmful powder materials with large quantity and wide range, has many problems, such as low production efficiency, low accuracy, low reliability, and so on.

The dynamic quantitative metering methods for powdery materials such as weighing type, compound type, nuclear type and so on have been improved, which has promoted the development and application of high efficiency and high accuracy dynamic metering technology. At present, the resistance strain type mechanical sensor developed by ourselves is mainly used in our country. Its dynamic measuring precision is generally only about 5%, which is similar to volume measurement, and its long-term stability is poor, especially the burden belt which is easily damaged. The need to change belts frequently increases maintenance costs, labor intensity and, more importantly, production. Based on Archimedes' principle, a new type of mechanical measurement sensor for powder materials is studied in this paper. The buoyancy weighing sensor overcomes its inherent defects such as temperature drift, creep and zero drift, which leads to low accuracy and poor stability of dynamic
quantitative measurement[4].

2. Dynamic buoyancy weighing system of increasing compensation system

2.1 Material weighing system
The quantitative weighing of materials includes electric vibrating feeder, weighing hopper, buoyancy weighing sensor (weighing sensor 1 and weighing sensor 2), comparison amplification circuit, AC click, computer and so on. The weighing sensor 2 is a compensation sensor. As shown in Figure 1.

![Figure 1: Structure diagram](image1)

![Figure 2: Material buoyancy weighing system diagram](image2)

2.2 Buoyancy weighing part
The feeding equipment shown in Figure 2 is the electromagnetic vibration feeding system of increasing compensation system. The system is driven by a vibrating motor, and the feed rate is determined by the magnitude of the motor's vibration. It is suitable for the situation where the material flow is poor and the precision of ingredients is high. Such as raw materials, powder granular materials and so on. Weighing and measuring system is the core link of dynamic quantitative weighing system and the key to ensure the accuracy of quantitative weighing. The weighing and measuring system mainly includes the weighing hopper, the buoyancy weighing sensor and the weighing measuring instrument, especially the buoyancy weighing sensor is the important link.

This study increased compensation device, as shown in Fig. 2. Weighing sensor 2 is the compensate part 2, it can effectively compensate for the error due to buoy vibration.

2.3 Transfer function of dynamic buoyancy weighing system
The transfer relation of the system is shown in Fig. 3. There are three nodes in the system, which are divided into three parts: the sensing part of the weighing float, the mechanism of displacement conversion and the part of electromagnetic transformation.

![Figure 3: Transfer function of dynamic buoyancy weighing system](image3)

2.4 Key techniques of comparative compensation method
According to previous research, we simplify the weighing system into mass-spring system based on material vibration as shown in Fig.4. We assume that the buoy’s movement is \( x_1(t) = x_1 \sin \omega t \) and the feed bin hopper’s movement is \( x_2(t) \). The weight of the feed bin hopper (include material) is \( M \), the equivalent stiffness of the supporting system of the feed bin hopper is \( K \), the equivalent stiffness of the is \( k \), the mass block is \( m \) and the damping ratio is \( B \), we can obtain that:
\[ Bx''_1 + k(x_1 - x_2) + mx_2' = 0 \] \hspace{1cm} (1)

\[ Bx''_1 + kx_1 = -mx_2' + kx_2 \] \hspace{1cm} (2)

So, the differential equation can be written as:

\[ \frac{x_2(s)}{x_1(s)} = \frac{B s + k}{-ms^2 + k} \] \hspace{1cm} (3)

Based on the MATLAB simulation experiment, this model meet the low-frequency vibration compensation condition\(^1\):

\[ 0 = w_m - M g = w_0 \frac{w_0}{w} - M g (1 - \frac{w_0}{w}) . \]

**3. Experimental verification**

By adding the comparative compensation method, the stability and reliability of the weighing data of the buoyancy weighing sensor are obviously increased, as shown in Table 1.

| Num | Before (kg) | After (kg) | the difference compare the exact value |
|-----|-------------|------------|---------------------------------------|
|     |             |            | before | after |
| 1   | 400         | 398.14     | -12.18 | -7.01 |
| 2   | 430.45      | 421.18     | 25.3   | 16.03 |
| 3   | 361.88      | 382.1      | -43.27 | -23.05 |
| 4   | 386.96      | 396.13     | -18.19 | -9.02 |
| 5   | 434.61      | 415.19     | 37.49  | 10.04 |
| 6   | 368.02      | 385.09     | -37.13 | -20.06 |

**4. Conclusion**

The research and experimental results show that in the weighing process of powder materials, the low frequency small vibration of buoyancy weighing system leads to the instability of its data, which can be corrected by adding compensation sensors and adopting comparative compensation method. The accuracy of weighing data is improved.

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