Research on the Computer Controlled Velocity Simulation Device for Continuous Totalizing Automatic Weighing Instruments

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Abstract. Continuous totalizing automatic weighing instruments is widely used in many industries, and need to be tested under different conditions especially for different temperature, humidity and electrical disturbance. Usually this kind of weighing instruments are very large and can not be put into such test environments, thus a test sample without belt conveyor is needed. Due to the working principle of continuous totalizing automatic weighing instruments, the test sample may include not only essential part of weighing instruments such as load cell, indicator, and load receptor, but also a device to simulate the displacement of the belt. In the paper, a device that can simulate the velocity of the belt is researched, it can generate square pulse signals to the test sample, thus the sample can operate as normal belt weigher. The configuration of the device is discussed and example is given to show its effectiveness.

Keywords: Continuous totalizing automatic weighing instrument; Servo motor; Encoder; Pulse signal.

1. Introduction

Continuous totalizing automatic weighing instruments (also called belt weigher) are one kind of automatic weighing instruments, they are widely in many industries such as mining and transportation industries. Their belt can convey loose materials. When materials pass through the load cell, the instrument can weigh the mass of the materials. Figure 1 shows the diagram of the belt weigher. The essential weighing part of belt weigher including load cells which measure the force caused by the material passing by on top, the indicator which usually perform analogue to digital conversion of the output signal of load cell, calculate and display the weighing indication, weighing table or load receptor, displacement transducer which provide information either corresponding to the displacement of a defined length of the belt or proportional to the speed of the belt. This is different from other kind of weighing instruments because the belt weigher weigh materials continuously. In fact, the belt weigher detect the flowrate of the material passing through the belt and measure the displacement of the belt, then the belt weigher can get the mass of the materials.

Many belt weighers are used related to legal metrology and need to be tested. The OIML recommendation OIML R50 is on type evaluation of belt weigher. According to OIML R50, during OIML test of belt weigher, it need to be tested on different temperature point, and also high temperature and high humidity. Usually these test need to be carried out in climate chamber. However, the dimension of the belt weigher is usually very big, so the belt weighers nomrally can not be put inside the chamber directly. Thus usually only essential weighing part without belt need to be tested, and since the belt is removed, how to simulate displacement transducer is a problem. By far, many manufacturers use inner
simulated velocity and time signal of the indicator to simulate displacement transducer device, but these signals do not come from outside, and is quite different from real situation. In order to simulate the real situation and be suitable for the type evaluation test of belt weighers, a device to simulate velocity of the belt is suggested in this paper. The design character is given in section 2, and an example is given in section 3 to illustrate the effectiveness of the device, and a conclusion is made in section 4.

![Diagram of the belt weigher](image)

**Figure 1.** Diagram of the belt weigher

2. Design of the Device

2.1. The Working Principle of the Belt Weigher

The belt weigher weights materials continuously, the load cell measures the force caused by the passing material, the displacement transducer measures the velocity of the belt, thus the mass indication of the material can get as follows:

\[ Q = \frac{mv}{W_L} \]  
\[ I = \int Q \, dt \]

here \( Q \) is the flowrate, \( m \) is the load, \( v \) is the velocity, \( W_L \) is the weigh length, and \( I \) is the indication of the totalization.

In the real system, the displacement transducer is usually a wheel with an encoder. The wheel is installed that it can touch the belt and rotate with the belt, thus its rotate speed is proportional to the speed of the belt. If the wheel rotates, the encoder generate pulse signal to the indicator, then the indicator can calculate the velocity of the belt and get the flowrate of the belt weigher. For the test sample, the belt is removed, so the encoder can not generate signals. In this case, the encoder can be connected with a servo motor to generate pulse signals which can simulate the velocity.

2.2. The Design of the System

According to the working principle of the belt weigher, the device to simulate the velocity of the belt weigher need to supply controllable pulse signals to the belt weigher, thus the system contains the following parts.

1) Control computer

The control computer is used to control the device, it has input interfaces, which can allow operators to set the frequency of the out signals, and control the rotate speed of the servo motor to the desired the frequency.

2) Servo controller and servo motor

This part is rotate at the speed controlled by the computer. Through a coupler, it can drive the encoder to generate the pulse signals.

3) Encoder and output interface

Encoder can generate the pulse signals, and the frequency of the signals is proportional to the speed of the servo motor. The frequency and the speed of the servo motor has the relationship:

\[ v_r = \frac{f}{f_0} \]  

Here \( f \) is the frequency of the output signals, \( f_0 \) is the number of pulses per round, \( v_r \) is the rotate speed of the servo motor.

4) Power system
The encoder need 5 V supply and the device has a power system to convert AC 220 V to DC 5 V, and supplies to the encoder.

3. Example

Figure 2 shows a device to simulate velocity of belt weigher. In this device, the frequency range of the output signal is 100 kHz. For the encoder, the number of pulse per round is 2000. The computer has a touch screen, and operator can easily set the parameter of the device, and set the desired frequency. The device is connected with a test sample of belt weigher, the parameter of the belt weigher are: Max = 200 kg, \( W_L = 1 \text{ m} \), \( v = 1 \text{ m/s} \). Then maximum flowrate \( Q_{\text{max}} \) can be calculate following (1) and \( Q_{\text{max}} = 720 \text{ t/h} \).

![Figure 2. Photo of the device](image)

\( Q_{\text{max}} = \frac{\text{Max} \times W_L}{v} \) \( = \frac{200 \times 1}{1} \) \( = 720 \text{ t/h} \).

According to OIML R50, at \( Q_{\text{max}} \), during the test, the belt weigher must totalizing at least 72 s. In this example, in order to simulate the speed of the belt weigher, the test sample is adjusted before the test, and the frequency of 1 kHz is set to be equivalent to the speed of 1 m/s. The test sample is put into the climate chamber and tested in different temperatures. At each temperature point, the sample totalizing at its maximum flowrate for 72 s, the theoretical indication is 14.4 t. The test results are shown in table 1.

| Temperature (°C) | Theoretical value (t) | Test result (t) |
|----------------|-----------------------|----------------|
| 20             | 14.400                | 14.399         |
| 40             | 14.400                | 14.397         |
| -10            | 14.400                | 14.402         |

At each temperature, the test sample totalizing twice, and the maximum error is -0.003 t, and maximum relative error is -0.021%, and the maximum permissible error for this belt weigher is 0.175%. As contrast, a signal generator is also used to simulate the velocity of the belt weigher, and the result is almost the same.

4. Conclusion

The velocity simulation device for continuous totalizing automatic weighing instruments is studied in this paper. The device includes a control computer, a set of servo controller and control motor, an encoder, and a set of power system. It can simulate the method to measure the velocity of the real belt weigher. A test example is carried out to shown its effectiveness.
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