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Research on the Influence of Weighing Accuracy Caused by the Position of Tension Wheel on the Electronic Belt-Conveyor Scale

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Research on the Influence of Weighing Accuracy Caused by the Position of Tension Wheel on the Electronic Belt-Conveyor Scale

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Abstract. In this paper, a Single- Idler electronic belt-conveyor scale is the Object of study. The contact force between the belt and the supporting roller is calculated by the finite element analysis software ABAQUS. The relationship between the tension distance of the tension wheel and the contact force between the belt and the weighing roller is obtained. The best stretching distance is found through analysis. And the conclusion which is the weighing error is different at the same stretching distance but the different weight of material is obtained. A compensation mechanism is proposed to improve the weighing accuracy.

1. Introduction

Electronic belt-conveyor scale is a kind of measuring equipment for weighing material continuously in the process of conveying solid bulk material by belt conveyor [2]. It can measure the instantaneous flow and cumulative flow of material on the belt without interrupting the material flow. It is widely used in industrial production. Figure 1 is the schematic diagram of the weighing principle of a single-idler electronic belt-conveyor scale used for conveying pulverized coal in an electric power plant. It consists of weighing roller, supporting roller, double hole parallel beam sensor, material and belt.

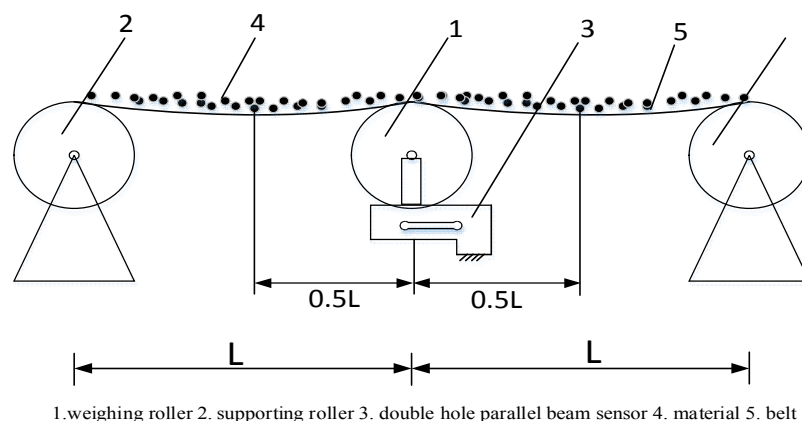


Figure 1. Simplified model of electronic belt-conveyor scale weighing system.

The weight of the material is measured by the sensor under the weighing roller. In order to simplify the research model, it is assumed that the material layer on the belt is uniform and the belt moves uniformly. Because the weight measurement of the electronic belt-conveyor scale is carried out by belt, the physical properties of the belt on the weighing process is very obvious [5]. Belt tension is considered to be one of the most influential factors of weighing. The weight of belt and the gravity of the material lead to a certain sag of the belt. It leads to the change of effective weighing interval measured by weighing roller, thus affecting weighing precision. As shown in Figure 2, the tensioning device of the electronic belt-conveyor scale changes the sag of the belt by adjusting the position of the tensioner wheel.

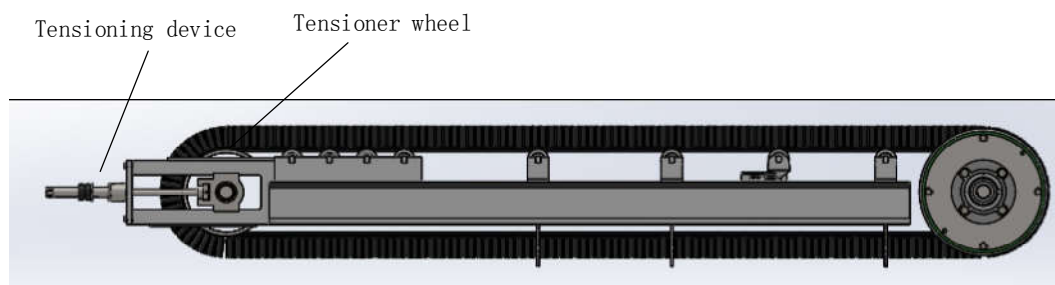


Figure 2. 3D model of electronic belt-conveyor scale.

In order to study the relationship between belt tension and weighing accuracy. In this paper, the finite element analysis software ABAQUS is used to simulate the weighing system of the electronic belt-conveyor scale. By changing the position of the tension wheel and the weight of the material, a series of conclusions are obtained, so as to improve the weighing accuracy of the electronic belt-conveyor scale.

2. Establishment of Finite Element Model of Weighing System

2.1. Geometric Model

In order to improve the accuracy and effectiveness of the whole analysis, the geometric model should be used to ensure the integrity of the weighing system of the electronic belt-conveyor scale [3,4]. The weighing system comprises a belt, a tension wheel, 5 supporting rollers, two span idlers and a weighing idler, and two double holes parallel beam sensors and other supporting accessories. It is necessary to adjust the tensioning wheel to the proper position before the actual work, so as to make the belt maintain a certain tension. The belt width is 800mm, thickness is $H=8.5\text{mm}$, two span roller distance is 800mm, the weighing roller theory effective bearing area $S=0.4 \times 0.8=0.32\text{ m}^2$.

2.2. Material Parameter

Query manual [1] the elastic modulus of the conveyor belt is $E=2.5243\text{GPa}$, and the Poisson's ratio is 0.46, the density is $\rho=1437.5\text{kg/m}^3$. Because the pulverized coal is evenly placed along the left and right sides of the belt, and its gravity has always been vertical downward, in order to simplify the calculation steps and shorten the calculation time, the weight of the pulverized coal can be reduced to the belt. Through the calculation the belt density in 10mm coal seam thickness is $\rho_1=2260.5\text{kg/m}^3$ and 20mm thickness of coal seam is $\rho_2=3084\text{kg/m}^3$. Q235 steel, elastic modulus $E=200\text{GPa}$ and Poisson's ratio of 0.26 are adopted for the rollers. The weighing sensor is made of stainless steel, the elastic modulus is $E=190\text{GPa}$, and the Poisson's ratio is 0.305. The other structure is made of 45# Steel $E=205\text{GPa}$ and the Poisson's ratio is 0.26.

2.3. Meshing and Boundary Conditions

Meshing the weighing system with C3D8R hexahedron element in ABAQUS, and the mesh is refined in the contact area of the weighing roller and the belt to get the high-quality meshing effect. The boundary condition is divided into two working conditions. Working condition 1: pulverized coal height is 10mm, left tension wheel left shift distance is 0mm, 2mm, 4mm, 6mm, 8mm, 10mm, 12mm, 14mm, loading belt gravity. Working condition 2: pulverized coal height is 20mm, left tension wheel left shift distance is 0mm, 2mm, 4mm, 6mm, 8mm, 10mm, 12mm, 14mm, loading belt gravity.

3. Calculation Result

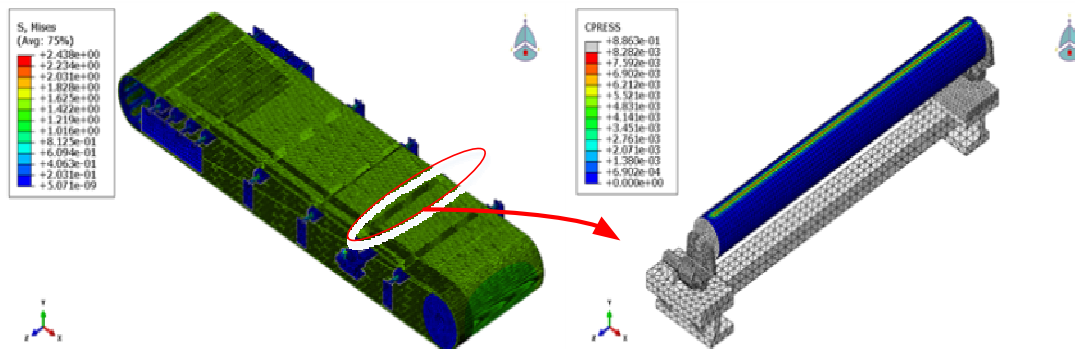


Figure 3. Stress nephogram of weighing system and contact pressure nephogram of weighing roller.

The post processing cloud chart is shown in Figure 3. The contact force between the belt and the weighing roller is the sum of the weighing of the two sensors, that is, the weight measured by the material in the measuring area. Therefore, the contact force between the belt and the weighing roller is analyzed in the simulation results. The calculation results are shown in Table 1.

Table 1. calculation results

Pulverized coal height (mm)	Contact force at tensile 0mm (N)	Contact force at tensile 2mm (N)	Contact force at tensile 4mm (N)	Contact force at tensile 6mm (N)	Contact force at tensile 8mm (N)	Contact force at tensile 10mm (N)	Contact force at tensile 12mm (N)	Contact force at tensile 14mm (N)
10	68.723	66.333	65.828	65.343	64.927	64.312	64.274	64.198
20	92.439	90.279	89.047	87.768	87.247	86.923	86.816	86.793

Analysis one: in order to intuitively reflect the laws of data, make a broken line diagram, such as Figure 4.

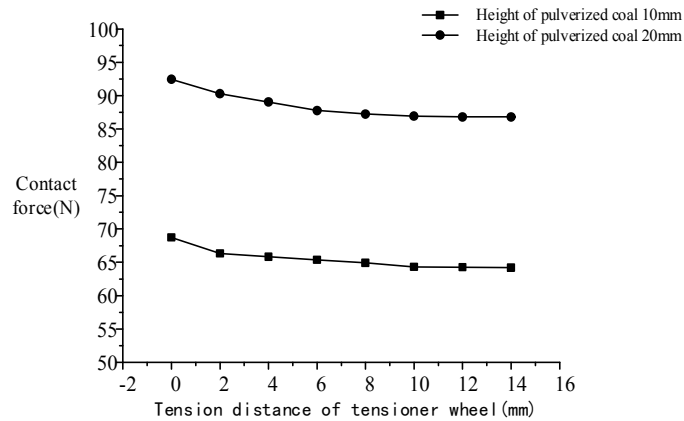


Figure 4. Calculation Results

When the height of pulverized coal is 10mm, the theoretical contact force between the belt and the weighing roller is:

$$F_1 = \rho_1 \times S \times H \times g = 60.255\text{N} \quad (1)$$

When the height of pulverized coal is 20mm, the theoretical contact force between the belt and the weighing roller is:

$$F_2 = \rho_2 \times S \times H \times g = 82.207\text{N} \quad (2)$$

Through analysis of figure 4, both when the pulverized coal height is 10mm and 20mm, it can be obtained that the contact force between the belt and the weighing roller decreases with the stretching distance of the tensioner, and approaches the theoretical calculation value, and it tends to be stable when the tensile distance is more than 10mm. We know that a large amount of belt tension will reduce the belt life, and the reliability of the whole weighing system has higher design requirements. So for this electronic belt-conveyor scale, the stretch distance 10mm is the best choice.

Analysis two: Under the two working conditions, the theoretical contact force difference is:

$$\Delta F = F_2 - F_1 = 21.952\text{N} \quad (3)$$

Figure 5 shows the relationship between the contact force difference and the tension distance of the tension wheel in the two working conditions. It can be seen that the difference of contact force is greater than 21.952N in all the 7 stretches. This situation shows that when the height of weighing material increases, the absolute error of weighing will increase without changing the tension distance of tension wheel.

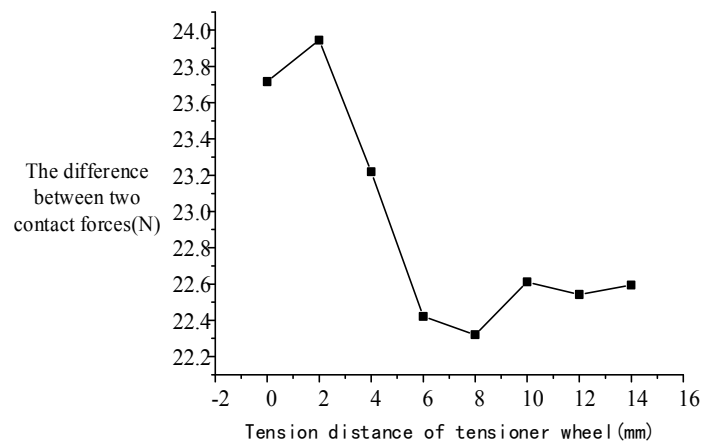


Figure 5. The relationship between the contact force difference and the tension distance of the tension wheel in the two working conditions

Based on the above analysis, it is proposed that when the height of pulverized coal increases, the output signal should be compensated appropriately in weighing signal acquisition to improve the weighing accuracy.

4. Conclusion

Every electronic belt-conveyor scale has its own tension wheel 's best position. The weighing accuracy is the highest at this position. The optimum stretching distance of tension wheel on the electronic belt-conveyor scale analyzed in this paper is 10mm.

When the height of the material increases, the absolute error of the electronic belt-conveyor scale will increase. In order to improve the weighing accuracy, it is necessary to compensate for the output signal in the weighing signal acquisition.

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