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Central Discharge and Start Timing Design Problem of Intermediate Drive Belt Conveyor

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Abstract. With the widespread use of intermediate drive belt conveyors, how to properly design intermediate components and properly activate the belt conveyors is a major problem with such belt conveyors. This paper takes a medium-carrying belt conveyor in China as an example, and deeply discusses the impact of material unloading on the conveyor belt in the intermediate drive unit and the start-up timing of the head and middle motor, and puts forward reasonable suggestions for the belt conveyor. The design of the intermediate drive belt conveyor provides a reference.

1. Introduction

Belt conveyors play an important role in transportation in coal production. With the increase in coal mine production, the demand for large-capacity and long-distance belt conveyors is increasing, especially for intermediate-drive belt conveyors. The driving part is added to the middle part of the belt conveyor, which reduces the head driving load and disperses the tension of the conveyor belt while ensuring the transportation volume, thereby greatly reducing the occurrence of accidents. However, in the process of designing the belt conveyor with intermediate drive, it is necessary to pay attention to the problems of intermediate discharge point impact and motor start timing.

2. Impact of material unloading on the conveyor belt in the intermediate drive

Taking the intermediate drive belt conveyor of a main mine in China as an example (as shown in Figure 1), the known condition is: the belt conveyor is an intermediate drive belt conveyor, belonging to the drum unloading belt conveyor. Wherein the head drive portion has two drive rollers, and the intermediate drive portion has three drive rollers. The belt conveyor has a total length of 4601m, a height difference of 365m, a conveyor belt length of 9,850m, a normal running speed of 5m/s and a conveying bandwidth of 1.8m.

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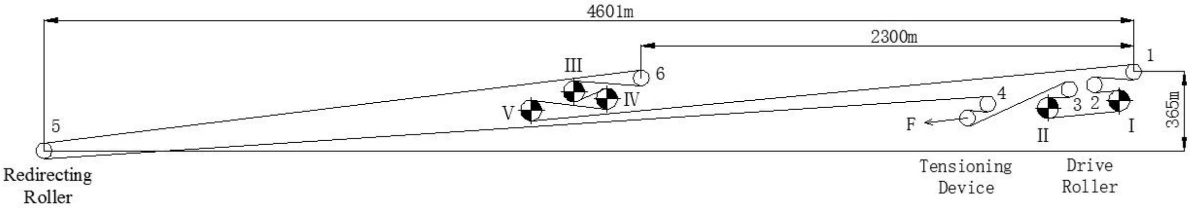

Figure 1. Schematic diagram of the intermediate drive belt conveyor layout.

When the coal is transported to the intermediate drive section, the coal mass will fall on the underlying conveyor belt in a parabolic trajectory due to the height difference of the two-stage belt conveyor, as shown in Figure 2. Since the height difference is large and the material quality on the conveyor belt is large, the impact force on the conveyor belt is large.

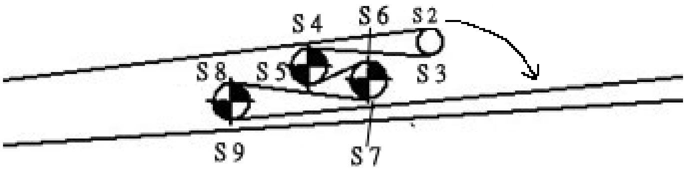

Figure 2. Schematic diagram of coal falling trajectory.

Set: the belt conveyor speed is v, the inclination angle is β, the drum radius is R, and the mass of the material on the conveyor belt is m, then: the centrifugal force of the material on the drum is: $F' = \frac{mv^2}{R}$.

As shown in Fig. 3, according to the literature [1], the supporting force of the material at the point of separation from the drum is:

$$F = mg\cos\gamma - \frac{mv^2}{R} \tag{1}$$

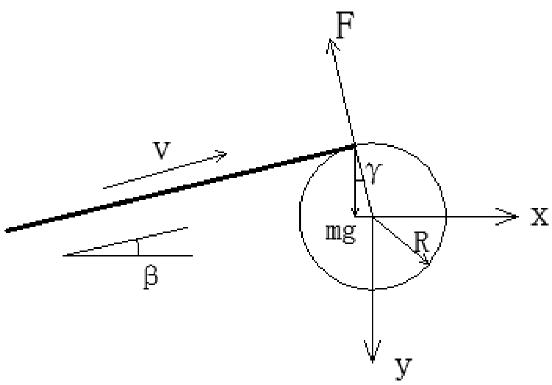

Figure 3. Schematic diagram of coal falling trajectory.

When the material is thrown away from the drum, F=0, it is:

$$\frac{v^2}{Rg} = g\cos\gamma \tag{2}$$

It is known that the conveyor belt speed v = 5 m / s, the drum diameter D = 1840 mm (i.e., R = 0.92 m), then: $\frac{v^2}{Rg} = 2.7728 > 1$ constant greater than $\cos\gamma$. It can be seen from the literature [1] that the coal block transported by the conveyor belt does not make a circular motion when entering the tangent point of the conveyor belt and the drum, and then falls off the drum. at this time: $\gamma = \beta$.

It can be seen that at the point of tangency of the conveyor belt and the drum, the coal block is separated from the conveyor. When the coal is dropped, the speed of its shaft and shaft are:

$$\begin{cases} v_x = v\cos\beta \\ v_y = -v\sin\beta \end{cases} \tag{3}$$

After the elapse of time t seconds, the position of the coal block is:

$$\begin{cases} x_t = \int_0^t v\cos\beta dt - R\sin\beta = vt\cos\beta - R\sin\beta \\ y_t = \int_0^t (-v\sin\beta + gt)dt - R\sin\beta = -vt\sin\beta + \frac{1}{2}gt^2 - R\cos\beta \end{cases} \tag{4}$$

It is known that the height difference of the coal block h=1m, then:

$$h = v_y t + \frac{1}{2}gt^2 \tag{5}$$

Available: coal bridging time is t≈0.4888s.

Therefore, when the coal is dropped onto the conveyor belt, the speed in the y direction is:

$$v_{yt} = v_y + gt = -v\sin\beta + gt = 4.7898m/s \tag{6}$$

According to the impulse theorem Ft=mv, take the buffer time t=50ms, if m=100kg, the impulse F=9579.6N; if m=200kg, the impulse is F=19159.2N.

In summary, at the intermediate drive, due to the falling of the coal block, a certain impact force is exerted on the conveyor belt. Because of this large force, it can cause greater damage to the conveyor belt. Therefore, the conveyor belt is prone to failure at the point where the coal block falls, and a buffer device should be added here to reduce the impact of the throwing coal.

3. Start Timing Control

Since the conveyor belt is a viscoelastic body, it takes a certain time for the dynamic tension to propagate, especially for a long-distance belt conveyor, and the propagation time is long. If this period of time is short, the roller and the conveyor belt are prone to slip; if this period of time is long, the tension of the conveyor belt return section will be large, causing certain damage to the conveyor belt. When the intermediate-drive belt conveyor is started, the head drive motor is started first, and when the conveyor belt tension wave is transmitted to the intermediate drive portion, the intermediate drive motor is restarted.

According to the literature [4] [5], the calculated elastic modulus of the conveyor belt is:

$$E' = \frac{E}{1 + \frac{q^2 g^2 l_g^2}{12 S_a^3} EB} \tag{7}$$

Where, E is the actual elastic modulus of the conveyor belt, N/m; q is the mass per unit length, including the mass per unit length of the conveyor belt and the material, kg/m; l_g is the distance between the two rollers, m; S_a is the average belt tension of the conveyor belt in the measuring section, N.

The force balance equation of the conveyor belt unit is:

$$\frac{\partial S(x,t)}{\partial x} dx = F_a(x,t) + W(x,t) g dx + q g dx \sin\beta \tag{8}$$

In the formula, S is the belt tension, N; F_a is the inertial force, N; $W(x,t)$ is the line resistance, N; q is the sum of the unit mass of the conveyor belt and the load, kg/m.

If you ignore the friction, assume $\beta = 0$, then :

$$\frac{\partial S(x,t)}{\partial x} dx = F_a(x,t) = q a dx = q dx \frac{\partial^2 U(x,t)}{\partial t^2} \tag{9}$$

Then :

$$\frac{\partial S(x,t)}{\partial x} = q \frac{\partial^2 U(x,t)}{\partial t^2} \tag{10}$$

According to the vibration equation of the string:

$$\frac{\partial^2 U(x,t)}{\partial t^2} = c^2 \frac{\partial^2 U(x,t)}{\partial x^2} \tag{11}$$

In the formula, c is the elastic wave propagation speed.

Substituting equation (11) into equation (14):

$$\frac{\partial S(x,t)}{\partial x} = q c^2 \frac{\partial^2 U(x,t)}{\partial x^2} \tag{12}$$

Because $S(x,t) = E' B \varepsilon$, therefore:

$$\frac{\partial S(x,t)}{\partial x} = \frac{\partial}{\partial x}\left[E' B \frac{\partial U(x,t)}{\partial x} \right] = E' B \frac{\partial^2 U(x,t)}{\partial x^2} \tag{13}$$

The elastic wave broadcast speed can be obtained by combining (16) and (18):

$$c = \sqrt{\frac{E'B}{q}} \tag{14}$$

According to the parameters of the middle drive belt conveyor of Tongyu Mine, it is known that: l_g = 1.5m, E = 2.925N/m, B = 1.8m, S_a = 15000N, then:

Elastic wave propagation velocity at no load (q=95.4kg/m):

$$c = 455.781 m/s \tag{15}$$

When there is load (set q=150kg/m) elastic wave propagation speed:

$$c = 237.846 m/s \tag{16}$$

It can be seen that the elastic wave broadcasting speed is different due to the different loads on the conveyor belt. Since the distance between the head drive and the intermediate drive is 2300m, the motor at the intermediate drive should start 5.05s later than the head drive motor when there is no load. When there is load, the motor start time should be determined according to the actual situation of the load.

4. Conclusion

In this paper, the dynamics analysis of the intermediate driving belt conveyor of Tongtong Mine of Shanxi Datong Tongmei Group is carried out, and the existing problems are pointed out. The loading force of the intermediate driving point is analyzed and the improvement suggestions are put forward. According to the actual situation of the load, the reasonable starting timing of the belt conveyor is deduced, so that the belt conveyor is more stable when starting, and the stability of the starting link is solved. It provides a reference for the design of intermediate belt conveyors.

Acknowledgments

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