

Research and review of high-power coal tilt down shipped belt conveyor's safe brake

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Abstract — Aiming at coal power tilt belt conveyor brake problems, through the establishment of the mechanical model of braking system, this paper derives braking torque, acting, and the relationship between heat capacity, computer control dynamic braking load as the reference variable deceleration. PLC control technology implements automatic starting of electrical conditions and electrical conditions. Using online testing with a speed sensor signal automatic overload protection system and a variety of flexible brake conversion, on starting, braking process of analysis are carried out. Discussed the safety of the hydraulic brake line monitoring system applications, and several common principles and characteristics of the brake devices were compared. The braking of the brake adaptation speed and dynamic load control technology and security of outlook, to meet the coal mine production safety requirements.

Keywords- Coal downward transport belt conveyo; High-power; brakes; Brake control; Research

1. Introduction

With the next shipment of high-power coal mine belt conveyor tilt to long distance large-capacity belt speed development, high [3], certainly will ask its braking device more safe, reliable, as “used in coal transport belt conveyor brakes under technical conditions (MT 912-2002)”and “coal mine safety rules” first 373 article 6 of paragraph 1 [5], request braking torque controllable power, has reliable braking, realizing the function for cars moving moment balance mechanism and underground flameproof requirements etc. But now because of all sorts of causes mine conveyor downtime, coasters, skid, stockyard, brake damage etc. Occurs frequently [4], but also for safety production in coal mine, therefore continuing study brings hidden danger of coal mine safety belt brake, applicability also become very important. Based on the next shipment of high-power coal mine belt conveyor tilt the technical characteristics, transmission principle, through the establishment of a brake mechanics model is derived, braking torque, work and heat capacity, according to the relationship between the dynamic load setting up reasonable braking reducing speed. PLC control technology achieve power generation condition and electric automatic starting conditions, using belt speed sensor to the realization of automatic overload protection, starting, braking process analysis. The essay probes hydraulic brake safety on-line monitoring system and the application of several normal braking devices compares the principle and characteristics. To brake, controllable brake technology and safety are discussed. Analysis has been brake research review to compare the differences, inductive application technology characteristic, for high-power coal tilt shipped belt conveyor under braking device must use can control technology, brake reducing speed and dynamic load adapt, has higher reliability, safety, meet the mine production requirements.

2. High-power coal tilt shipped belt conveyor under braking principle

High-power coal tilt down shipped belt conveyor braking, not only to overcome the more big load torque braking, while also absorb the intense heat generated by braking. Although adopted explosion-proof measures, according to thermal explosion, the quantity of heat of theory excessive accumulation, there may still be ignites coal mine underground gas [6], this research braking reducing speed, heat and power, to improve the

relationship between the next shipments of high-power coal tilt of belt conveyor braking safety performance. Establish the mechanical model shown as shown in figure 1 [7] [10].



Figure 1. Next shipment belt conveyor mechanics model diagram

Among them is convert to drive roller M1 and the load torque, Belt conveyor J1 is equivalent to the driver of the roller of inertia, $\omega(t)$ is conveyor the angular velocity driving drum, M_z is braking system provides braking torque, I is a brake drum and drive gear ratio between, η for driving drum brake and the mechanical efficiency between.

$$\frac{i \cdot M_z}{\eta} - M_1 = J_1 \cdot \dot{\omega}(t)$$

There is braking torque for:

$$M_z = \frac{\eta (J_1 \dot{\omega}(t) + M_1)}{i} = \frac{\eta (J_1 a + R M_1)}{R \cdot i} \quad (1)$$

Here a is reduction in conveyor speed, general take $0.1-0.3 \text{ m}^2 / \text{s}$; R is the radius of the drive pulley.

Design of the brake, the design should have spare capacity of the brake torque, and generally calculated on the value of 1.5 times. Brake in the braking of the brake is:

$$W = \int_0^{V_0} p(t) dt = \int_0^{V_0} M_z i \dot{\omega}(t) dt$$

Obtained after integration:

$$W = \frac{\eta (J_1 + R M_1 \cdot \frac{1}{a}) \cdot V_0^2}{2 R^2} \quad (2)$$

Where V_0 is running speed conveyor, m / s ;

From equation (1) shows: when the braking deceleration a check is small, the brake braking torque can be smaller, but by the formula (2) shows, this time by braking the brake power required is also large, requiring more heat capacity also large, in the field use, there are improperly set brake braking torque, braking time is too long, resulting in a lot of heat, making the brake temperature is too high this reason, but when the braking deceleration a too large, although the heat generated by smaller, but requested brake braking torque, the conveyor system on the mechanical impact is also large, and even damaged or broken gear reducer shaft accident. Therefore, under normal circumstances, for high-power coal belt conveyor should take a tilt control system, namely the use of computer and PLC technology to automatically capture the dynamic load signal, flexible set the adaptive braking deceleration, and to ask the brake have greater heat capacity and good heat dissipation to avoid such incidents, [10].

3. High-power coal tilt down shipped belt conveyor braking equipment research and review

The data shows [10], more present application is still disc brakes, hydraulic brake, hydraulic brake etc., its brake function consummating, the performance, the direct impact on the next shipment belt conveyor safety and reliable operation. Use show that these brakes although security is better, but mostly didn't resolve braking torque load and the rational matching and adaptive problem, but also the future of a period brake point of research.

3.1. Explosion-proof self cooling disc brakes

Explosion-proof disc brake mainly by mechanical brake disks and controllable hydraulic station composition, its working principle is applied to work through the brake disc friction braking force and

produce braking torque, through hydraulic station in the size of the adjustment brake hydraulic pressure, which can adjust is adjusted the size of braking torque. Hydraulic station adopted electro hydraulic proportional control technology, so braking system braking torque can automatically adjust to work on, realize good controllable braking. General braking discs in low speed shaft installed, as figure2 shows.

Request linear velocity is not more than 10m/s. In order to make the brakes have good performance of radiator, guarantee the brake disc temperature, according to fan principle to make hollow structure of the brake disc forced cooling method, the braking process absolutely no more than 150 °C. Used in high power coal mine next shipment belt conveyor tilt on need to install the soft starter, to keep power balance. The braking device of the main components of the realization of automatic control is electro hydraulic proportional control valves, can press given input signal continuously proportional to control the direction, pressure and fluid flow, make the brakes can get different braking force.

Calculation of braking torque:

$$M_z = 2nNfR$$

Where: n - Brake on the number;

Mz - Braking torque;

N - Brake effect of positive pressure in the brake disc, it adjust the hydraulic pressure and spring pre-volume-related;

f - Gateway between the skin and the brake disc friction coefficient

R- Equivalent to the brake disc brake radius.

3.2. Hydraulic Brake

When using motor-driven hydraulic pump output torque is required, the same hydraulic pump driven by conveyor systems will also have power, when the hydraulic pump on the conveyor is the same size produced by the damping torque, when the damping torque is large enough, the system will Braking moving conveyor. Under normal circumstances for the reduced size of the pump, hydraulic pump arranged in the high-speed multi-axis, the specific Figure 3.

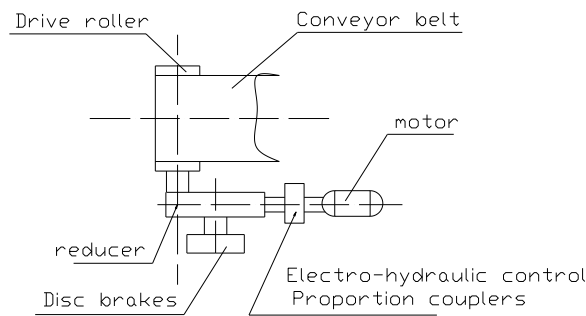


Figure 2. Explosion-proof self cooling disc brakes

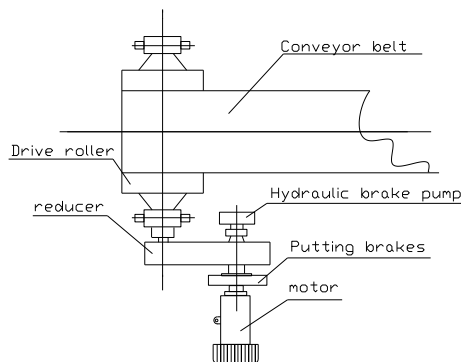


Figure 3. Hydraulic brake arrangement

According to the work principle is different, hydraulic brake can be classified into two braking forms, one kind is surge braking, and according to the work principle is next type [12]:

$$M_z = \frac{\Delta p \cdot q}{2\pi} = \frac{(P_b - P_0) \cdot q}{2\pi}$$

Where P_b -pump outlet pressure;
 P_0 -is the pump inlet pressure;
 Q -is the pump displacement.

It can be seen from the above equation, when the pump outlet pressure regulator can adjust the size of P_b braking torque M_z size, in order to achieve moving conveyor can be controlled.

The other is the brake debugging, and its working principle is that when changing the flow of the hydraulic pump, it can change the conveyor speed can be controlled in order to achieve dynamic brake. Hydraulic brake system by controlling the oil pressure or flow can be done under the belt conveyor ideal braking deceleration. The braking power under the belt conveyor generally uses high pressure and high flow piston pump. When the conveyor is brake, the displacement is at maximum. While the conveyor normal operation, the displacement to minimum. In the braking process, a lot of brake heat away from the hydraulic oil and cooling by the water cooler; when the oil temperature is too high, the hydraulic components prone to failure, while the oil flow because the cycle of operation and large temperature changes, easily degenerate, further affect the reliability of the hydraulic control system; the same time when the conveyor car fixed, because the disclosure of hydraulic pumps and hydraulic systems, must be specifically added to set the brake push rod motor.

3.3. Hydraulic brake

Hydraulic brake hydraulic turbine fixed in real terms is a hydraulic coupling (also known as non-rigid coupling), blocks the flow of the impeller rotation have a great moment of resistance (braking torque), so that the conveyor slowdown brake.

Braking torque calculation formula [11]:

$$M_z = n_b^2 D^5 g_n \lambda_B \rho$$

Where: n_b - pump wheel speed;
 D - pump wheel cycle's diameter;
 λ_B - pump wheel torque coefficient;
 ρ - of the working media's density;
 g - Acceleration of gravity.

The above equation, when the structural parameters fixed, the hydraulic braking torque and braking system the speed of the pump wheel, wheel speed is zero when the pump when the hydraulic braking system can brake torque output; and pump wheel moment coefficient and the coupling filled the area, filling the more the larger the impeller torque coefficient, so the filling volume can be adjusted to change the size of the braking torque to achieve the next belt conveyor can be controlled dynamic. As the pump is not a rigid connection with the turbine wheel, hydraulic brake coupling and long life. Hydraulic brake coupling directly affects the placement of its own size. It is generally placed in the high-speed shaft. Hydraulic brake system is not possible to move the transport mechanism to zero speed. When wheel speed is less than 400r/min the mechanical brake stop must be used. In its cooling system and hydraulic control hydraulic braking system, there are also poor quality when oil temperature is too high or when the oil prone to failure.

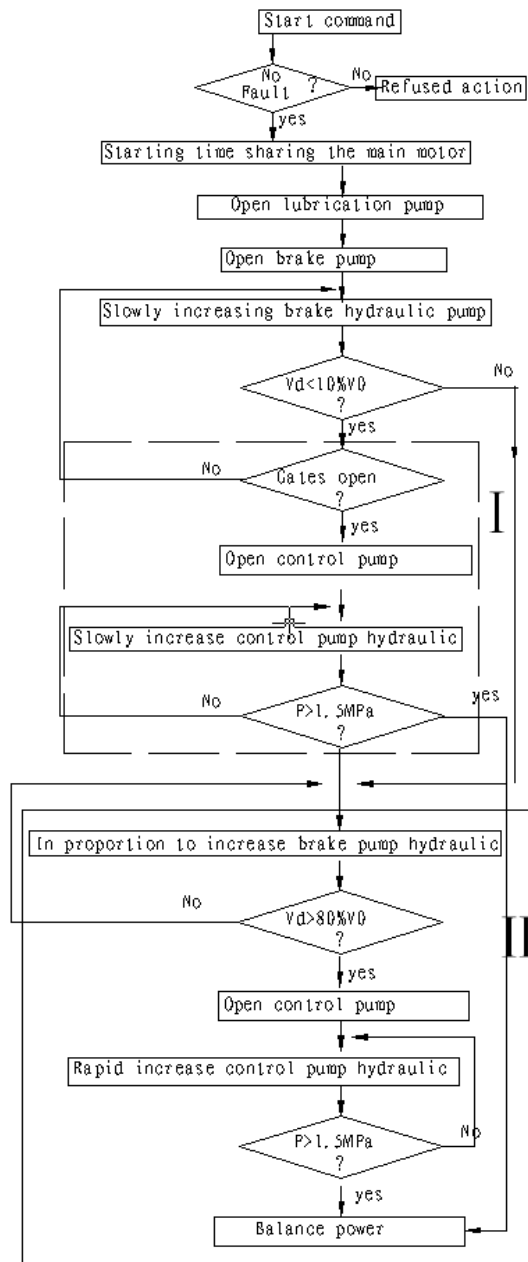


Figure 4. Braking flowchart

3.4. Mucus can control the mobile device

Mucus controllable braking device is using a friction piece in viscosity fluids to the friction transmission torque. From the frictional piece fixed, active friction slices from the rotation, Lord, the oil cylinder piece in frictional pressure, will produce friction between them. Just change adjustment control oil cylinder pressure, friction slices between compaction force changes, thus changing its friction torque, satisfy conveyor braking requirements. Normally when oil inter membrane space decrease, braking speed increases, the braking torque increases, instead will decrease. So the brake, in conveyor must constantly decrease oil inter membrane space, can guarantee certain braking torque. Mucus controllable braking device no impact of simple structure, braking, braking torque adjustable control, and to achieve automatic overload protection, brake safe and reliable, has the good use effect, it is especially suitable for long distance, high-power coal tilt down shipped belt conveyor.

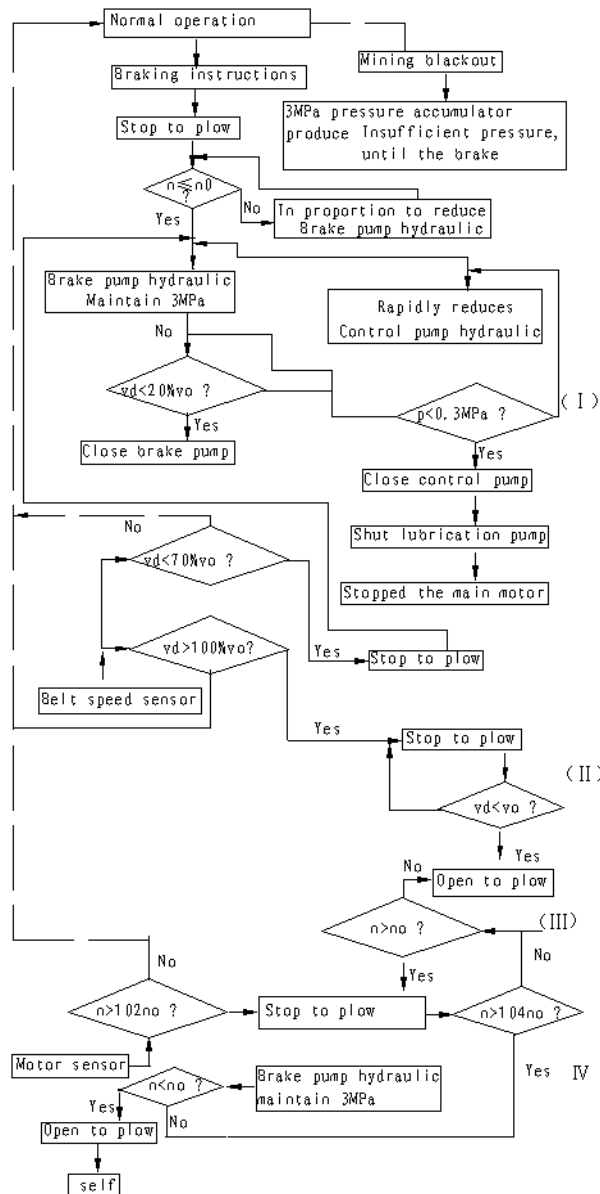


Figure 5. Braking flowchart

4. Start braking equipment selection and the automatic control process technology research

4.1. Application of composite brake

The above analysis shows that liquid viscous soft starting device can be used to start, and the disc brake and controllable braking torque reliable for cars. Consider working environment, maintenance costs run requirements for high-power coal tilt down shipped belt conveyor, appropriate chooses liquid viscous soft starter and disc brake devices to cooperate to use, the better the scheme for conveyor provide starting and braking force.

4.2. Electronic Control System

Electrical control system design by the console, cabinet, integrated security systems, various sensors and switches. PLC is the control center to realize the high and low voltage motor control, operational status and fault detection system processing. Brake control for starter, mainly so that the liquid viscosity control of the soft starter in the 0.3-2MPa hydraulic proportional output, control tape speed, so that the brake hydraulic disc brakes in the 0.5-10MPa output to control braking torque.

4.3. Starting Process

Coal tilt of the next shipment belt conveyor there are two conditions: starting conditions and power generation condition of electric. Different condition and start-up has the very big difference, need liquid viscous soft starter and the cold disc brake, figure 4 coordinated actions for starting process. In racing or light load condition, loose after sluice of belt conveyor won't automatically run or runs slowly, according to electric conditions (figure box I starting part). Gates open later start controlling pumps and slowly increases control hydraulic, when control unit to rated pressure balance motor power.

In the case of overloaded or fully loaded, after the belt will be loose gate under the action of the load down the acceleration, the status of the Offer Electric Start (Part II frame). When the belt speed is over the rated speed with 10%, gradually increase the brake oil pressure, the braking torque decreases until zero. When the tape speed reaches the rated belt speed of 80%, the start control the hydraulic pump and control the rapid increase in soft-start device to enable rapid integration of the friction plates, the main motor of the braking force into the operation of the conveyor. When the control oil pressure reaches the rated working pressure, balance the motor power.

4.4. Braking process

Figure 5 for high-power coal tilt of the next shipment belt conveyor braking process, including four situations: general braking (part I), sliding protection brake (part II), speeding brake (III part) and power outages brake (IV) [11]. Normally, when brake instruction is sent, if motor speed is not more than the rated speed, the system is in electric conditions. At this time in proportion to reduce brake hydraulic until the motor droop to the rated speed, then press the electric conditions braking. When the belt speed sensors detect belt speed too high or low, the belt conveyor, causing a skid phenomenon of conveyor belt, and may be torn, worn by friction fever cause conveyor belt, even burning exploded, when belt speed is too low, the conveyor belt may be something to stop to squeeze live, coal, electric braking, when conditions by belt speed is high, explain system overload, should stop to coal, etc belt speed returning to normal after continue to coal.

When the motor speed sensors detect motor speed is high, the more than that load torque the biggest power braking torque motor, there is danger, in addition to stop flying outside, still need to use coal for brake equipment. When the power is the optimal, to prevent braking conveyor belt sliding, directional control valve accumulator by electromagnetic brake pump 3MPa instead of the brake hydraulic produced, make the belt conveyor, until the moderate slowdown brake. In addition, when there is other fault, parking brake press general way braking.

5. Conclusion

- Through the establishment of a brake mechanics model is derived, braking torque, work and heat capacity, the relationship between the reasonable design braking reducing speed can avoid mechanical impact, avoid reducer broken teeth, broken axle phenomenon, beneficial to the safety production in coal mine
- High-power next shipment belt conveyor braking device must use can control technology, reducing speed can be automatic matching with transportation load size, meet braking torque, power off automatic protection, controlled more dynamic torque balance mechanism of coal mine safety requirements and have signs.
- Apply more successful braking device has a disc, hydraulic, hydraulic and mucus controllable etc, in effect, for cars controllable, install each has its characteristics, as shown in table 1.
- For high-power coal tilt down shipped belt conveyor brakes, want to combine condition use, automatic control brake priority selection. To demand higher occasions, all can cooperate with hydraulic push rod brake, achieve soft and hard braking speed brake, realize the level
- Choose liquid viscous soft starter and disc brake devices to cooperate to use, the better the scheme for high-power coal mine next shipment belt conveyor tilt provide start-up and braking force.
- Using a computer and PLC technology automatically generating condition and electric condition, use the starting signal measured belt speed sensor system, to realize the automatic overload protection general braking, sliding protection braking, speeding braking, and power outages braking flexible adaptive conversion.

- Research results of hydraulic braking equipment safety online monitoring system, realize the braking torque on-line monitoring, can prevent hydraulic braking equipment failure from fatal accidents, greatly improving the next shipment of high-power coal tilt of belt conveyor brake system reliability, safety.

6. References

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Table 1 various brake differences of characteristics

Brake type	disc	Hydraulic type	The hydraulic	Mucus controllable
Working principle	Dry friction	Liquid pressure dynamic	Fluid pressure static	Wet rubbing
controllable	good	good	good	good
Effect for cars	good	no	poor	good
reliability	good	General	General	better
Explosion-proof performance	Good	Good	Good	Good
Maintenance costs	Low	Low	High	General