Application of Liquid Viscous Soft Starter in Conveyor

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Abstract

The necessity of the application of soft starter in underground coal mine is analyzed. The working principle of liquid viscous soft start is introduced from the aspects of mechanical system structure, electrical control system and hydraulic control lubrication system. At the same time, the advantages of the liquid-viscous soft-start phase compared to other soft-start phases are given.

Keywords

Belt conveyor; soft start; liquid viscosity; principle.

1. Application of Soft-start Device in Mine

After the first belt conveyor was manufactured, it was widely used in the construction of coal mines, power plants, warehouses, mines and large-scale projects because of its advantages such as large capacity, high efficiency, and good continuity. After years of development, belt conveyors have developed to standardization and serialization. Belt conveyors are the most widely used in coal mines. They will produce the scattered coal that is transported through multiple belt conveyors and transported in a continuous manner to where it is needed. Belt conveyors have now become one of the major equipment for coal mining operations.

For the installation and use of large belt conveyors, it is necessary not only to consider proper power matching, but also to rationalize the layout, but also to solve the impact of large belt conveyors on the power grid and belt during the start-up process, that is, the common soft-start problem. Soft start is directly related to the working performance of the conveyor. Unreasonable startup will have the following consequences:

(1) If the starting tension is too large, it can easily cause a tape break accident. After the motor is energized, it will drive the drum to start quickly, and the longer and longer conveyor belt will start instantly. The tight edge will generate huge inertia and impact tension. The tension is several times that of normal operation, and it is easy to cause belt tearing and broken belt accidents. It has caused major hidden dangers to the safety production of coal mines. In order to prevent breakage, the strength of the conveyor belt must be increased, which in turn will make the conveyor cost too high and consume a lot of energy during operation.

(2) It is prone to slippage and belt fire accidents. The belts commonly used in wells are at least a few hundred meters or more, and as many as several kilometers, such a long belt will inevitably require a large driving force at startup. The momentary start of the conveyor main drum generates a large driving force and is prone to slippage. If it is started at the full load of the conveyor, the degree of slipping will be more serious. During the skid, friction between the roller and the conveyor belt generates a large amount of heat, which not only damages the belt, but also easily causes a fire.

(3) Large impact on the power grid. The momentary start of the motor will be accompanied by a huge load, which will cause the motor to generate several times more current and torque, which will cause a greater impact on the power grid, and the motor itself and its load mechanical equipment will bring adverse effects.

The "Coal Mine Safety Regulations" stipulates that a soft starter must be added to the belt conveyor to ensure reliable and stable operation of the belt conveyor. At present, for the soft start of high-angle, high-power belt conveyors, the following technologies are mainly used at home and abroad:

(1) Variable-speed hydraulic coupling, which is an early common soft-start device, can extend the start-up time and improve the full-load starting performance of the conveyor.

(2) Inverter, using a frequency converter to achieve soft start has better performance, but at present there is no domestic and foreign developed high-voltage explosion-proof inverter that can be reliably used in underground coal mines.

(3) CST system, a mechanically controlled system CST (Controlled Start) developed by DODGE

Transmission System), which can greatly improve the transmission performance of the belt conveyor.

(4) Liquid viscous soft starter the liquid viscosity viscous soft starter developed by Shandong University of Science and Technology with international advanced level.

After comparing various speed control methods, it can be seen that the liquid viscous transmission is better than the hydrodynamic mixer in the high-speed section, and the performance is better than the electric control speed control in the low-speed section. Not only can the motor start with zero load, but it can also realize stepless speed control of the drive roller with a large range of speed regulation. In addition, it has advantages over other speed control methods in manufacturing costs, heat dissipation, and ease of maintenance. Its advantages are summarized as follows:

(1) Can make the high-power motor start without load to reduce the impact on electrical and mechanical;

(2) Resolved the problem of heavy-duty starting of the belt conveyor;

(3) The liquid viscous soft starter can provide adjustable, smooth, impact-free starting torque;

(4) According to the characteristics of the conveyor, you can set the starting curve;

(5) Under normal working conditions, the system has high working efficiency and low power consumption;

(6) It has good matching characteristics with the motor and can fully utilize the maximum torque of the motor;

(7) Multi-motor drive power balance can be achieved when needed;

(8) The stepless speed regulation of the conveyor can be realized to meet different working requirements;

(9) Automatic overload protection can be achieved when the conveyor is overloaded;

(10) It is suitable for occasions where coal mine explosion prevention requirements apply.

Because the liquid viscosity transmission and speed control has unparalleled superiority compared to the electric control type speed control and hydraulic speed control, the liquid viscosity transmission speed control device has high economic and social benefits on the coal mine underground conveyor. The liquid viscous transmission speed governing device is used to connect the motor and the main drive roller of the conveyor, and is used as a clutch and governor between the motor and the drive roller. In actual use, it is often named as a liquid-viscous soft-start device. It can be equipped on medium and large conveyors to extend the life of conveyors and transmission systems. It can also reduce the impact on the power grid and improve the service life of the motor. In addition, the maintenance cost of the liquid-viscous soft-start device is low, which can save a large amount of manpower and financial resources. The strong safety factor required for belt conveyors has been reduced from the original 7 ~9 to 4.5~ 5.5, which reduces the purchase cost of the conveyor and saves the cost of electricity.

2. Structural features and working principles

The liquid viscosity soft starter consists of three parts: a mechanical system, a hydraulic control lubrication system, and a supporting electrical control system.

2.1 Mechanical system structure and working principle

The mechanical system structure is shown in Figure 1.

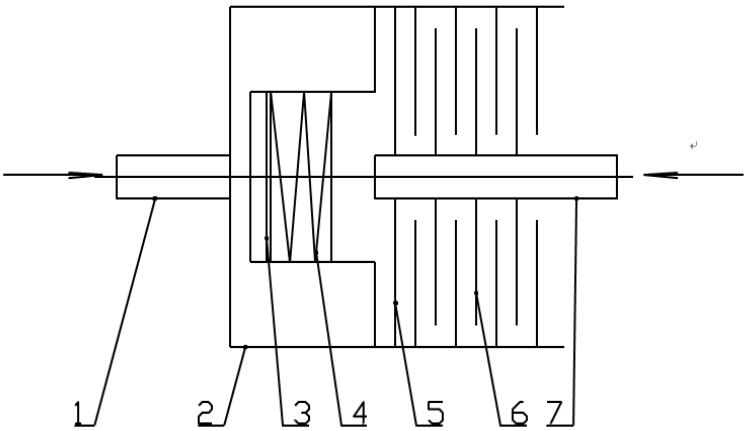

Fig.1 Mechanical structure diagram of liquid viscosity soft start system

1—input shaft; 2—case; 3—control cylinder; 4—spring;5—active friction plates; 6—slave friction plates; 7—output shafts

The liquid viscous soft starting device uses the viscosity of the liquid, that is, the oil film shear force, to transmit the torque. Its structure is shown in Fig. 1. Its structure consists of main and driven shafts, master and slave friction plates, control cylinders, springs, housings and seals. When the active shaft drives the active friction plate to rotate, the oil film drives the rotation of the driven friction plate through the viscous fluid between the friction plates, and the thickness of the oil film between the main and driven friction plates can be adjusted by changing the oil pressure in the control cylinder. The output speed and torque of the driven friction plate enable various drive requirements and controllable soft start functions of the belt conveyor.

The torque equation of the liquid viscous soft start system is:

$$M = \frac{\pi \cdot \Delta\omega \cdot \mu \cdot n}{2h}\left(R_2^4 - R_1^4\right) = \frac{\pi \cdot \omega_1 \cdot \mu \cdot n}{2h}\left(R_2^4 - R_1^4\right)(1-i) \tag{1}$$

In the formula

ω_1——Active friction plate angular velocity，rad/s；

μ——Fluid dynamic viscosity，Pa·s；

n——Number of films；

h——Film thickness，m；

R_2——Contact surface outer diameter of main and driven friction plates，m；

R_1——Contact surface inner diameter of main and driven friction plates，m；

i——Speed ratio of main and driven friction plates。

From equation (1), it can be seen that for a certain structure of the liquid viscous soft starter, the output torque is proportional to the angular speed difference Δω of the master and slave friction plates, and inversely proportional to the film thickness h. Therefore, by adjusting the thickness of the oil film, the output torque and angular speed difference can be easily adjusted to achieve the purpose of speed control.

2.2 Electric control system

The electrical control system uses a programmable controller to perform soft start control on the belt conveyor. Most of the high-power belt conveyors use multi-motor drive mode. The control method is to solve the slippage and overspeed protection of the conveyor belt and the drive roller by comparing the speed detection signal of the conveyor belt with the output speed signal of the soft start system. Through the control of a computer, the proportional valve control current of the closed-

loop control system is used to adjust the power balance between the motors. At the same time, through the comprehensive security control box to achieve conveyors along the parking, conveyor belt deviation, temperature, smoke, tear tape, broken belt, coal and other protective actions.

2.3 Hydraulic Control Lubrication System

The hydraulic system of the liquid viscous soft starter consists of a lubrication system and a control system. The role of the lubrication system is to force the heat generated between the friction plates to form a shear oil film between the friction plates when the conveyor is performing soft start or speed regulation. The control system adjusts the gap between the friction plates to change the thickness of the oil film so that the output speed changes as needed. The composition of its hydraulic system is shown in Figure 2.

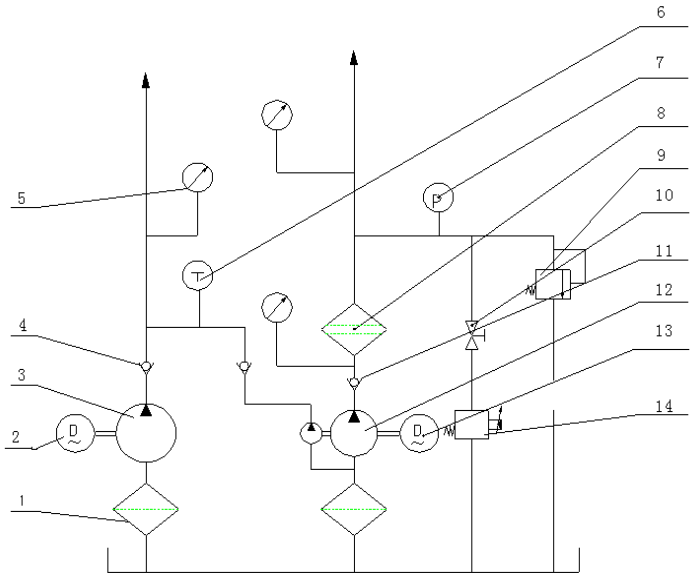

Figure2 Hydraulic schematic

1 - coarse oil filter, 2 - lubrication pump motor, 3 - lubrication pump, 4 - large flow check valve, 5 - pressure gauge, 6 - temperature sensor, 7 - pressure sensor, 8 - fine oil filter, 9 - Safety valve, 10 - throttle valve, 11 - check valve, 12 - control pump, 13 - control pump motor, 14 - electro-hydraulic proportional valve

3. Conclusion

The liquid viscous soft starter can be widely used in the soft start, speed regulation and soft braking processes of coal mine underground belt conveyors and hoisting transport machinery, engineering machinery, military machinery, fans, and water pumps. Can greatly improve and enhance the start-up, operation and parking performance of machinery and equipment, well eliminate the impact on electrical and mechanical equipment, achieve automatic overload protection of host equipment, power balance and other functions, improve the working efficiency and reliability of machinery, Save energy and reduce equipment use costs.

The liquid-viscous soft-start device as a drive system can realize slow, full-load, and smooth start-up of the belt conveyor, load balancing of multiple motors, and reduction of technical requirements for electrical and other components. Improve the reliability and service life of belt conveyors. After the belt conveyor uses liquid-viscous soft-start, it can reduce the strength of the first-order belt and reduce the 30% to 40% of the motor capacity, which has obvious economic benefits. With the development of the coal industry, liquid-viscous soft-start devices will surely become more and more widely used.

References

[1] Hou Youfu, Huang Min, Zhang Yongzhong, Dynamic characteristics and control technology of belt conveyor [M]. Beijing: Coal Industry Press, 2004 (5): P53~66.
[2] Chen Weifeng. Reasonable selection of soft starting method for large-scale mine belt conveyor[J]. Coal Mining Machinery, 2007, 28 (2): 164-166.
[3] Zhang Yuping. Comparison and selection of soft starting methods for main inclined shaft belt conveyor [J]. Research, 2008, 9: 75-77.
[4] Li Qishen. Implementing soft start-up of belt conveyor with electric drag technology [J]. Hoisting and Transport Machinery, 2001 (Supplement), 46-50.
[5] Song Weigang, Zhan Xin, Wang Yuanyuan. Comparative study of large-scale belt conveyor driving device[J].Journal of Engineering Design, 2004(12): P302-311.
[6] Tao Yongqin, Li Bing. Comparative analysis of soft starter of belt conveyor [J]. Mechanical Engineer, 2005 (8): P128-129.
[7] Wei Yan, Zhao Jiaxiang. Liquid Viscous Transmission Technology [M]. Beijing: National Defense Industry Press, 1996.