

Design, Research and Application of Complete Equipment for High Temperature and Large Capacity Ultra Long Distance Belt Conveyor

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Abstract. The complete set of equipment technology for high temperature and large transport capacity ultra long distance belt conveyor has innovatively developed new technologies and devices such as rapid maintenance and replacement technology of idler, high temperature resistant idler, special conveyor belt and joint form, intelligent dynamic controllable double tension double storage belt device, multi drive point dynamic balance motor synchronous control technology, which has solved the problem that the high temperature resistant belt conveyor technology is short distance, low belt speed and small transport capacity, Its conveying system is composed of multiple conveyors, with many system failure points, large transfer station area and high system investment. It has created a new road for the development of high efficiency and low energy consumption belt conveyor in China, and accumulated valuable experience in design, manufacturing, installation and commissioning.

Keywords: High Temperature Resistance; Large Capacity; Ultra Long Distance.

1. Introduction

As a continuous conveying equipment for bulk materials, the belt conveyor system is widely used in steel, coal, ports and docks, power, building materials and other national economic industries. It is a large and versatile product. However, the traditional belt conveyor has limited high-temperature resistance and is mainly used for conveying materials at room temperature.

In recent years, with the technical progress of relevant companies at home and abroad and the increasing demand of users for high-end equipment, foreign manufacturers such as Robins, KOCH of Germany, Rey of France and other companies have accelerated their technological progress in belt conveyors, especially in the field of long-distance, high belt speed and large volume transportation of high-temperature materials, which has greatly improved the market competitiveness of their products. According to the data, the maximum temperature of clinker transported by the high-temperature and large capacity ultra long distance belt conveyor in the world is 120 °C, the transportation distance is 10.45km, the belt width is 1400mm, the belt speed is 3.15m/s, and the transportation capacity is 2000t/h.

In order to expand the application field of belt conveyor products, break through the technical limit that domestic long-distance belt conveyors can only transport materials at room temperature, and break the foreign technical monopoly in the design of high-end high-temperature resistant cement clinker transport belt conveyors, an ultra long-distance high-temperature resistant belt conveyor was developed.

The complete equipment system for high temperature resistant and large capacity ultra long distance belt conveyor has a total length of 22.331km and an annual conveying capacity of 10.5 million tons. Among them, the longest single machine distance is 11.75km, the highest belt speed is 4m/s, the maximum transport capacity is 3000t/h, and the maximum material temperature is 175 °C. As the lifeline of the logistics storage terminal, it is a complete belt conveying equipment with the largest comprehensive parameters, the most complex working conditions, and the greatest technical difficulties independently designed, manufactured and commissioned by China.

2. Technical Design and Research Contents of Complete Set of Equipment for High Temperature Resistant and Large Capacity Ultra Long Distance Belt Conveyor

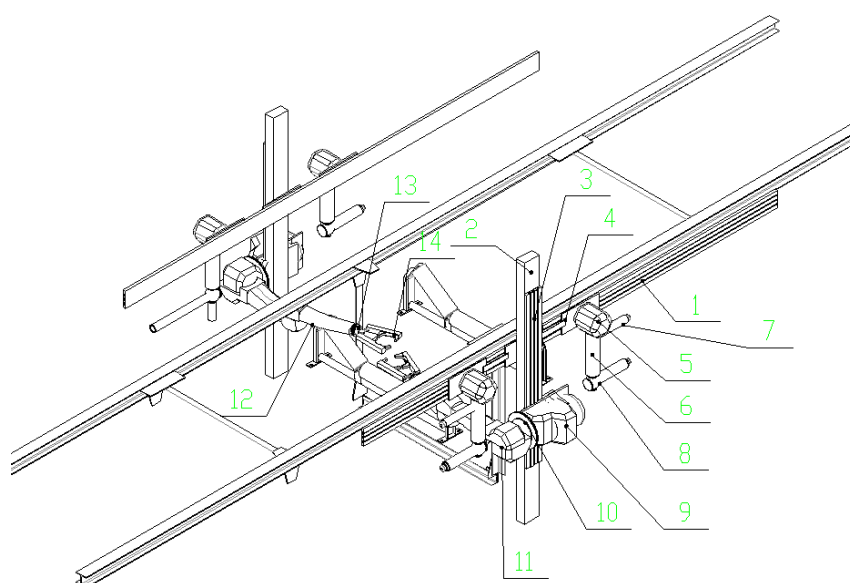
The transit storage and transportation project cross multiple roads, tunnels, high and low voltage transmission and transformation lines along the way. The terrain fluctuates up and down with 5 angles of turns. Its design difficulty is rare in the world. If the project is designed according to the conventional design, it is very easy to suffer from unstable driving output, easy slipping of driving drum, reduced belt safety factor, excessive force on equipment, unstable operation of the whole machine and other adverse conditions. Moreover, the conventional conveyor belt, idler grease and tensioning device cannot meet the working conditions of the belt conveyor system. These are also the technical problems urgently needed to be solved by experts in the belt conveyor industry at home and abroad.

2.1 Technical Proposal

2.1.1 Intelligent Maintenance Equipment of Belt Conveyor and Rapid Maintenance and Replacement Technology of Idler

The complete belt conveyor system has a long spanning distance and high material temperature, so the idler is the main part of its damage. If the traditional post maintenance method relies on manual inspection and manual replacement of the damaged idler, the work efficiency is low, the accuracy is difficult to ensure, and the quality of maintenance personnel is high. Because the belt conveyor system is in an extreme environment, its dust, high temperature materials, and transmission lines are erected high above the ground. The harsh on-site environment has caused great potential safety hazards for inspectors.

We have developed an intelligent maintenance equipment for belt conveyor, which can accurately detect the status of the conveyor system, timely transmit and collect information to the control center, and monitor the system environment online in real time, so as to achieve full automatic patrol inspection, automatic maintenance of vulnerable parts, temperature monitoring of rotating parts, and abnormal noise monitoring of important parts, and automatically alarm when potential accidents are found to ensure the safety and reliability of the belt conveyor system.



Carriage I 1, Connecting Plate I 2, Carriage II 3, Connecting Plate II 4, Carrier Belt Base 5, Carrier Belt Base 6, Telescopic Arm I 7, Telescopic Arm II 8, Base 9, Base Rotary Table 10, Boom 11, Jib 12, Grab Rotary Table 13, Grab 14

Figure 1. Structural Diagram Of Belt Conveyor Idler Replacement Device

The maintenance equipment we developed is equipped with a quick maintenance and replacement device for the idler and a idler supply and recovery device. First, the belt devices on both sides lift the tape, and then the manipulator reaches into the damaged position of the idler, grabs the damaged idler and puts it into the idler recovery bin, which is fixed by the slide rail clamp on the outer frame of the adjustable slide rail. The bin opening is a flap mechanism that can be put into the idler freely. After the idler is put into the bin, the flap is closed reversely to achieve only in and no out. Then, grab the new idler supplied by the automatic feeding bin and install it. Finally, take back the belt device, put down the belt, and complete the replacement function of the entire idler. This maintenance process can be carried out circularly. With the support of idler feeding and recycling equipment, the idler is automatically fed and recycled, which greatly reduces the maintenance time and reduces the user's work intensity and potential safety hazards for equipment maintenance.

2.1.2 Intelligent Dynamic Controllable Double Tension Double Belt Storage Device, Inertial Enhancement Device

The change of the thermal elongation of the belt used to transport high-temperature materials is irregular. The total amount of heat sources varies widely. The high-temperature materials extend the bearing surface of the conveyor belt, which increases the sag of the conveyor belt between idlers. The heat dissipation temperature of the materials varies with seasons and external temperatures. The longest single unit length of the conveyor system designed and developed for this project is 11km and the terrain is complex. Considering the influence of various factors. The thermal elongation of wire rope belt varies greatly. The materials distributed on the belt conveyor are heavy in quality and inertia. Under special circumstances, the speed of the belt at each point is uneven. The conventional tensioning device can no longer meet the stable operation of the system under various working conditions. It is very easy to slip the roller, shake the belt. When braking or sudden power failure occurs, there will be belt stacking, belt fluttering, and belt deviation at the space corner, which will lead to equipment failure to start, out of control parking, runaway and other major accidents.

In view of the above problems, by building the structure of the intelligent control system of the belt conveyor, the dynamic simulation of cross combination of dozens of working conditions was carried out, and an intelligent dynamic controllable double tensioning double storage belt device was developed. A fixed winch was added at the head for tensioning, which can simultaneously absorb the elastic elongation and irregular thermal elongation of the belt when starting or stopping, so as to solve the problems such as deviation, belt stacking, belt floating, etc. during the starting and braking process. It can also provide belt storage function, which is convenient for the maintenance and overhaul of the whole equipment. This is the first time in the application of long distance high belt speed and large volume high-temperature resistant clinker belt conveyor.

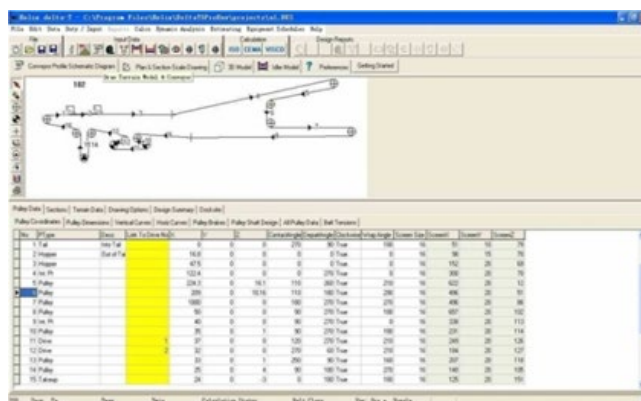


Figure 2. Dynamic Simulation Of Cross Combination Of Working Conditions Of Intelligent Control System Of Belt Conveyor

Through the dynamic analysis of various working conditions of the belt conveyor, it is found that increasing the downtime of the belt conveyor can effectively alleviate the impact of the conveyor belt.

Therefore, the inertia increasing device is designed at the high speed end of each drive unit, which is composed of flywheel, expansion sleeve, bearing seat, bearing, coupling, etc., which can prolong the shutdown time of belt conveyor under special circumstances, make the shutdown speed at each slope section basically consistent, and completely solve the belt impact phenomena such as surge, overlapping belt, and streamer at local sections of belt conveyor. Improve the stability and reliability of the system under various working conditions.

2.1.3 Synchronous Control System of Multi Drive Point Dynamic Balancing Motor

The longest belt conveyor in the complete set of equipment has a conveying distance of 11km. It adopts a multi-point driving arrangement at the head and tail. The driving points are far apart. Due to the large volume and high temperature of materials, a large range of changes in the total amount of heat sources, complex terrain along the way, elastic stretching of the belt and nonlinear changes in elongation, long and unstable transmission time of tension waves, the conventional motor control method will lead to uneven multi-point driving output, failure to respond in time when tensioning, roller slipping. In case of belt vibration, overlapping belt and streamer will be generated during braking, the belt at the space turn will deviate greatly, the equipment cannot be started, the parking is out of control, flying cars and other problems will impact the mechanical equipment greatly, and the whole machine cannot operate stably.

Through the dynamic analysis of the transmission time and elastic change of tension, the original theory of the propagation speed of tension wave is broken in the multi machine sequential starting control, and a set of belt elastic deformation and tension online detection and control theory unique to North Heavy Industry is formed. A dynamic mathematical model is established, and a master-slave synchronous control theory of a specific mode of multiple motors is formed by using intelligent algorithms. Applying this theory, the intelligent control system of belt conveyor is creatively constructed.

The system adopts the method of 'tension closed-loop control' to keep the tension of the whole belt within the safe range. A tension detection device is set at the head and tail. The collected belt tension signal is fed back to the central control room to detect the belt tension at the driving point and compare it with the preset value at the point (obtained through static and dynamic analysis and calculation). According to the preset working condition parameters, the output torque and speed of each motor are dynamically adjusted by the frequency converter to realize the intelligent control of the belt conveyor drive system. The drive motors are arranged at the first three ends and one layout. At the common drive point of the three motors at the head, the segmented motor synchronous control is adopted. At the initial stage, the middle stage and the operation stage of the conveyor, the corresponding dynamic mathematical model is established and the intelligent algorithm is used to carry out the specific master-slave synchronous control of the three motors. The motor can still achieve dynamic balance under complex system conditions, with high control accuracy, good response effect, stable system operation, small impact on mechanical equipment, and greatly improve the operating efficiency of the conveyor system. It avoids slip, belt stacking, system vibration and other failures caused by tension or load changes.

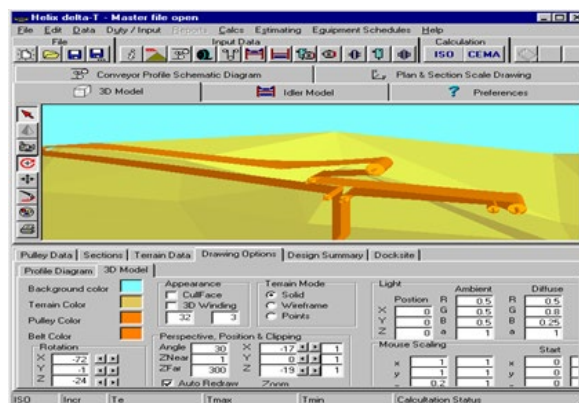


Figure 3. Multi Drive Point Dynamic Balancing Motor Synchronous Control System

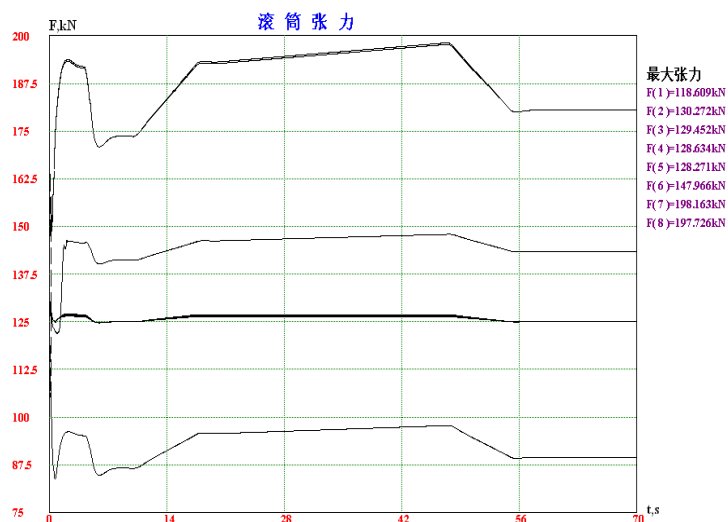


Figure 4. Pulley Tension Diagram Of Multi Drive Point Dynamic Balance Motor Synchronous Control System

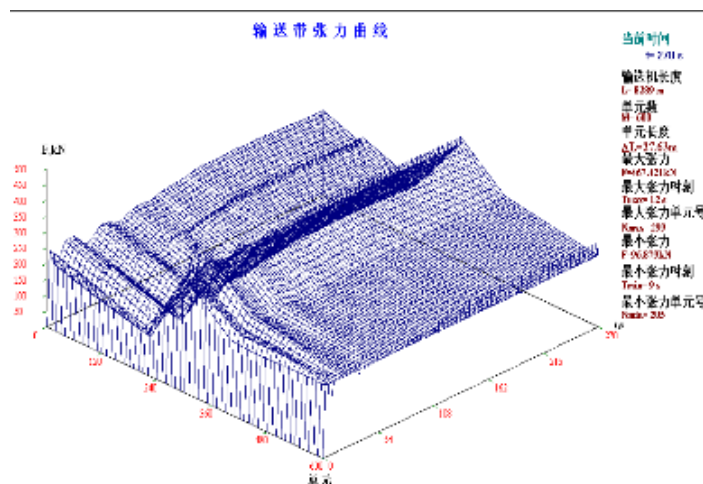


Figure 5. Conveyor Belt Tension Function Of Multi Drive Point Dynamic Balance Motor Synchronous Control System

2.1.4 New Type Idler with Low Rotation Resistance and Low Noise

Reducing the comprehensive simulation friction coefficient of the belt conveyor can effectively reduce the power consumption of the whole machine. Therefore, a lot of analysis has been made on various indicators that affect the simulation friction coefficient, and design ideas such as reducing the depression resistance, improving the installation accuracy, and using energy-saving idlers are proposed to make the comprehensive simulation friction coefficient approach the ideal indicators.

The number of idlers used in the belt conveyor is large, accounting for a considerable proportion of the total investment, and the size of its running resistance directly affects the energy consumption of the whole belt conveyor. The design adopts a new type of idler with low rotation resistance and low noise, a new type of idler with low rotation resistance, a "new type of hub bearing with low friction resistance", and improves the cage structure according to the characteristics of grease distribution inside the bearing. In coordination with the adjustment of the idler processing technology, the special high-frequency welded pipe with higher accuracy is selected for the idler skin, and the processing accuracy is guaranteed through the professional fully automated production line, thus reducing the rotation resistance of the idler and the radial runout value at both ends of the idler, and reducing the rotation resistance of the idler by 46%.

Collapse resistance is the main part of the running resistance. Therefore, reducing the collapse resistance is crucial to reducing the power consumption of the belt conveyor. Through the analysis of the mechanism of the collapse resistance, increasing the resilience of the conveyor belt can effectively reduce the collapse resistance. However, high resilience and high flame retardancy and wear resistance are interrelated and mutually restrictive. According to the characteristics of the transported materials, the theory of increasing elasticity and reducing resistance is put forward and applied to the design of belt conveyor. Through calculation, analysis and experiment, the resilience of a certain amount of rubber under the conveyor belt is increased, and the depression resistance between the conveyor belt and the idler is effectively reduced, so that the energy saving effect of the whole machine can reach more than 15%, saving more than 3 million yuan for the owner every year.

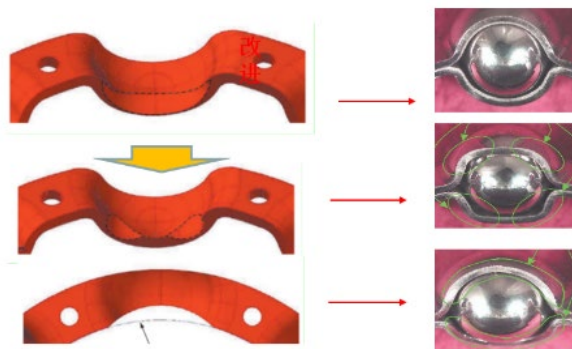


Figure 6. New Type Idler With Low Rotation Resistance

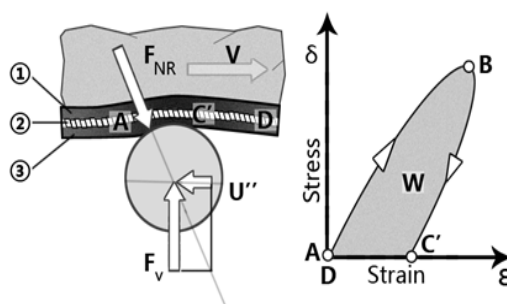


Figure 7. Mechanical Analysis Of Low Rotation Resistance And Low Noise Roller Collapse Resistance

2.1.5 Energy Saving and Environmental Protection Design of Particle Simulation Technology

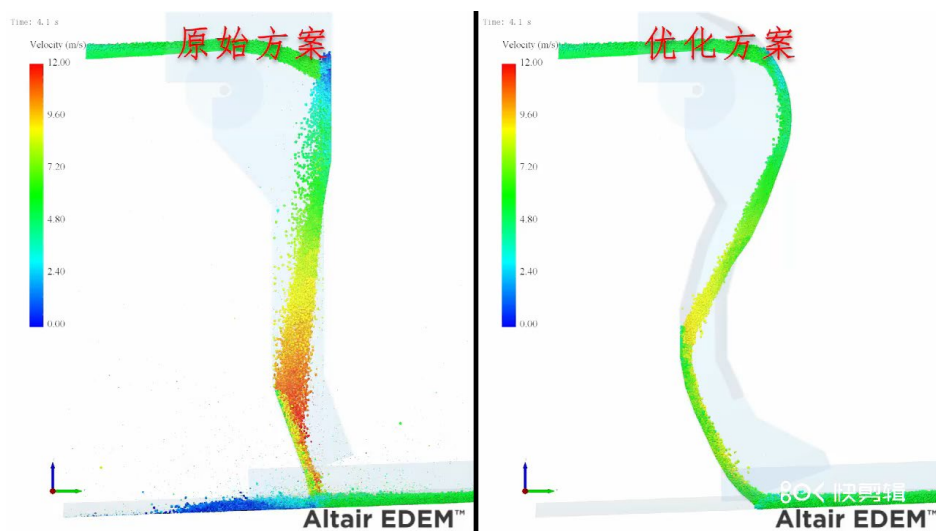


Figure 8. Dust Free Transfer Dynamic Simulation Based On Particle Simulation Technology

Using particle simulation technology and aerodynamics principle, the transfer system is designed for energy conservation and environmental protection. Through discrete element analysis, a reasonable transfer system structure is designed to change the "impact" of materials on the tank wall into "scouring", reduce the energy loss and noise during the transfer process, and keep the speed of materials passing through the transfer system consistent with that of the receiving belt conveyor, so as to reduce the generation of material dust; The principle of aerodynamics is used to make the dusty air enter the dust gas separation device and the adjustable dust resistance device, and then carry out automatic separation and dust removal such as inertia, gravity sedimentation and filtration. The dedusting air is discharged into the space through the atmospheric connecting hole, and the settled material dust falls back to the material surface. Through the application of the above technologies and methods, noise and dust can be reduced to achieve dust-free and low-noise operation of the entire conveying system.

2.2 Technological Innovation

The complete set of equipment technology for high temperature and large transport capacity ultra long distance belt conveyor has innovatively developed new technologies and devices such as rapid maintenance and replacement technology of idler, high temperature resistant idler, special conveyor belt and joint form, intelligent dynamic controllable double tension double storage belt device, multi drive point dynamic balance motor synchronous control technology, which has solved the conventional design of high temperature, large transport capacity and ultra long distance in the domestic and foreign belt conveyor industry, It is very easy to encounter technical problems such as unstable driving output, easy slipping of driving roller, low safety factor of belt, excessive force on equipment, unstable operation of the whole machine, and difficult maintenance. The complete set of equipment is designed for energy conservation and environmental protection, and the transfer system is optimized by using particle simulation technology to achieve dust-free and low-noise transfer; Using the theory of increasing elasticity and reducing resistance, the conveyor belt is optimized, the comprehensive simulation friction coefficient is reduced, and the power consumption of the whole machine is effectively reduced; A new type of idler with low rotation resistance and low noise is applied. Finally, the conveying system realized dust-free and low-noise operation.

3. Summary

The successful research and development of the complete set of belt conveyor with high temperature resistance, large transport capacity and ultra long distance has broken through the technical bottleneck of the complete set of belt conveyor system with high temperature resistance, long distance and cement clinker, and solved the problem that the high temperature resistant belt conveyor technology is short distance, low belt speed and small transport capacity. Its conveyor system is composed of multiple conveyors, with many systems failure points, large transfer station area, and high system investment.

It provides ideas for the research and development of energy saving technology for the whole belt conveyor, provides successful experience for the belt conveyor to achieve longer distance, larger transport volume, more energy saving and more environmental protection, and effectively promotes the technical progress of the belt conveyor industry. It has created a new road for the development of high efficiency and low energy consumption belt conveyor in China, and accumulated valuable experience in design, manufacturing, installation and commissioning.

It has met the needs of high temperature material transportation projects in building materials, metallurgy and other fields at home and abroad, broken the foreign technical monopoly in the design of high-end high temperature resistant belt conveyors, greatly improved the high-end market competitiveness of transportation products, and laid a solid foundation for comprehensively entering and occupying the world mainstream market.

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