Development Method of Fully Automatic Wire Winding Device Based on Dual Motion Control System

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Abstract: In the construction of overhead contact wire for electrified railways, the entire process of wire drawing is manually made, especially for the winding and fixing of the back tie wire. With the length of construction lines often reaching hundreds or even thousands of kilometers, the task of wrapping and fixing the back tie line becomes very heavy and cumbersome. In addition, whether the entanglement is firm, tightly attached, and smooth greatly tests the wrist strength and craftsmanship of construction workers. The comparison between teachers and beginners in construction is obvious, and it is difficult to ensure the consistency of construction standards. In response to the above issues, the fully automatic winding machine adopts a mechanical dual transmission design, a mechanical moving slide mechanism, a reduction motor, and a stepper motor control system to achieve winding process standards such as tight adhesion, reliability, and smoothness, and improve manual operation efficiency by 3-5 times.

Keywords: Fully Automatic; Railway Track; Fault Diagnosis; Dual Motion Control

1. Introduction

After anchoring the clue terminal of the high-speed rail transmission line, it is necessary to install a stay wire in the opposite direction of the anchoring to counteract the tension acting in the direction of the line, thereby reducing the load on the pillars and their foundations [1,2]. In the past, most of the old-fashioned methods used for cable turning and tying were iron pliers winding or manual winding and tying. The appearance of cable turning and tying after completion is shown in Figure 1. When binding iron pliers, in order to ensure the tightness of the winding, the clamp mouth of the iron pliers is in direct contact with the binding wire and steel strand. During the clamping process, it is very easy to cause damage to the anti-corrosion layer on the surface of the binding wire and galvanized steel strand. Although certain anti-corrosion measures have been added, it is highly susceptible to rusting in harsh outdoor environments, which affects the service life of the cable. When manually tying, use the binding wire to coil into a circle and use the tiger's mouth of the palm as a coiling tool. Although it can ensure that the zinc layer is not damaged, due to limited manpower, it is time-consuming and laborious, prone to loose and unstable binding, and can also cause some damage to the palm.

Figure 1. Appearance Diagram of Cable Turning and Binding Completion

The existing winding methods include not only manual operation, but also specialized winding devices for fine enameled wire coils and transmission line tie wire winding devices. The special winding device for fine enameled wire coils mainly consists of a bottom plate, a winding machine, a winding plate, an electric motor, a lubrication system, and a winding device. The arrangement of enameled wire in the wire rack is completed by controlling the speed of the winding plate's reciprocating shaking [3,4]. In practical operation, with the operator's proficiency and experience, as long

as they roughly grasp the shaking speed of the winding board, they can meet the requirements. This method belongs to a semi-automatic wire winding device, which requires manual adjustment of speed, has low efficiency, and requires the object to be wound to be threaded into the winding device. For the fixed high-speed rail wire that has been turned back, both ends are closed, and the threading method cannot be used, which is not very suitable. The transmission line tie wire winding device uses tie wires to fix the 10KV transmission line on pin insulators, and repairs and ties the damaged wires with tie wires [5,6]. This method consists of five parts: shaft, bearing, bearing seat, manual crank, and bracket. However, manual control of winding speed and tension is still used. In today's rapidly developing automation technology, there are obvious problems such as difficulty in ensuring consistency in the winding process [7,8].

In response to the above issues and the special working environment of high-speed rail wire turning, a fully automatic wire winding device based on a dual motion control system adopts a double gear transmission with notches to solve the nesting problem of wire turning, and uses a dual motion control system to achieve horizontal movement and lateral winding of the wire. Finally, the effectiveness of this method is verified through on-site experiments.

2. The Structure and Principle of a New Type of Winding Device

The device consists of a winding mechanism, a moving slide mechanism, a control system, and a power supply.

2.1 Winding Mechanism

The mechanism is mainly composed of a gear set, including: 1 driving wheel, 2 transmission wheels, and 1 working gear with notches, as shown in Figure 2. The deceleration motor provides power to the driving wheel, which drives two transmission wheels and drives the working wheel to rotate. The working wheel and the cable fixing bracket rotate around the cable and turn around. Design a large gap in the work wheel and fit it onto the cable head through the gap. The gears are designed according to national standards and are expected to be machined with metal. The binding wire fixing bracket adopts an adjustable damping design, which adjusts the binding tension through damping.

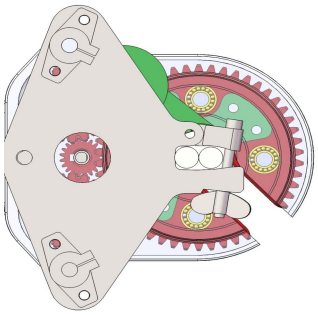

Figure 2. Structural Diagram of Winding Device Mechanism

2.2 Mobile Slide Mechanism

The mechanism consists of a bracket, a screw, and a stepper motor, as shown in Figure 3. The stepper motor works in conjunction with the deceleration motor, and for each revolution, the stepper motor moves the slide mechanism to drive the winding device to move horizontally. The limit device is installed on both sides of the moving slide mechanism, and when it moves to both sides, the automatic limit stops. During operation, the mobile sliding table mechanism is fixed to the cable by setting fastening buckles on both sides.

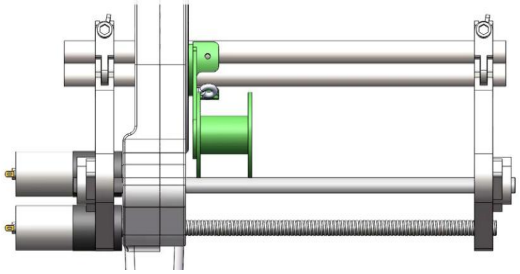

Figure 3. Structural Diagram of Mobile Sliding Platform Mechanism

2.3 Control System

The control system mainly includes: embedded processor, speed measurement (Hall) sensor, button input, reducer motor drive, stepper motor drive, display indication, and battery management.

The control system can achieve human-machine interaction through embedded processors and related input/output interfaces, control winding actions through deceleration motors, control moving slide actions through stepper motors, and achieve battery management. Embedded main control chip, using domestic macro crystal microcontroller STC32G12K128. The software program includes: stepper motor drive, reducer motor

control algorithm, human-computer interaction program, battery management, etc.

3. The Experimental Process of a New Type of Wire Winding Device

The prototype of a fully automatic wire winding device based on a dual motion control system is shown in Figure 4. The experimental process of the new wire winding device is described in detail below.

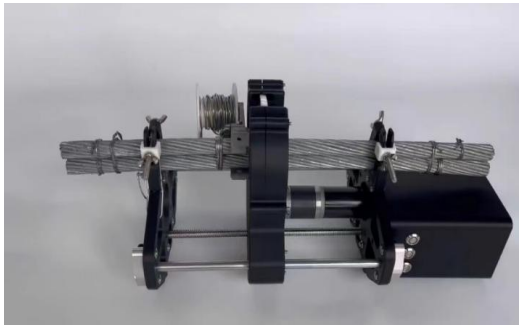

Figure 4. Prototype of Wire Winding Device Trial Production

3.1 Installation and Fixation of Cable Turning Tool

(1) Firstly, align the gear gap with the position of the winding mechanism gap, and at the same time, adjust the entire winding mechanism to the initial winding position of the cable return.

(2) Then place the fully automatic wire winding device in place from the side of the cable turning back, and at the same time, place the wire winding in the prefabricated coil in an "L" shape in the middle of the cable turning back to facilitate the later twisting of the wire.

(3) Adjust the buckles at both ends of the fixed wire winding device to firmly fix it on the cable head. During the winding process, as one side of the cable is fixed as a single line and the other side is fixed as a double line, the fixed handle can be combined to ensure that the secure position between the wire winding device and the cable head does not deform.

3.2 Winding Process

(1) Turn on the power switch of the device, and the power indicator will light up, indicating that the power is sufficient. If the power is insufficient, the indicator light will flash.

(2) Press the automatic winding button, and the winding device starts to work. The double gear transmission device, driven by the motor, starts to rotate counterclockwise around the cable. At the same time, the winding coil starts to wind the wire on the cable through the wheel guide groove.

(3) According to the different diameters of the pulling and winding wires, the winding direction and horizontal speed of the dual motion control system of the winding device can be adjusted. Here, four working modes are set for selection. At the same time, according to the winding process, the forward speed of the stepper motor can also be controlled through an external handle.

3.3 Fixed by Wire Winding

When the winding is completed, a suitable amount of twisted wire length should be reserved, and the wire should be cut with iron pliers. One end of the wire that was previously placed in the middle position of the "L" shape should be twisted with the end of the wire, and the entire winding should be fixed.

4. Benefits and Application Prospects

Through the development of this equipment, the automation and intelligence of the process of wire turning and winding can be achieved, the standardization of winding process can be achieved, and the consistency of construction results can be improved. At the same time, this equipment has the advantages of easy operation, portability, and long continuous working time. It only takes about a few seconds to complete a winding construction, which can greatly improve construction efficiency, save labor costs, and scientifically shorten the construction period. The specific benefits and application prospects include the following aspects:

4.1 Economic Benefits

In the construction and maintenance of high-speed rail overhead contact systems, the winding and fixing of the cable head is a necessary process with a high demand; Whether it is a newly built high-speed railway or the later operation and maintenance of the overhead contact system, a large number of automatic wire tying and winding equipment are required. This equipment can be mass-produced and promoted to the industry to meet the operational needs of new and old lines, and the economic benefits it will bring to the railway industry will be very considerable.

4.2 Social Benefit

The development of this equipment not only ensures the consistency of construction technology, but also reduces the workload of workers, greatly improves construction efficiency, scientifically shortens the construction period, and can also reduce the later operation and maintenance

5. Conclusion

The research on a new type of fully automatic wire winding device has solved the problems of difficult to ensure construction standards, large and heavy workload, and low construction efficiency in the process of high-speed rail electrification. The new fully automatic wire winding device utilizes a dual motion control system for wire winding, which can achieve winding process standards such as tight adhesion, firmness, and smoothness; Small in size, light in weight, and easy to operate, it can save a lot of time for the winding and fixing of the cable. The development of a new type of fully automatic wire winding device has significant application significance for various binding and winding situations in future construction processes.

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