Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
© 2024 SCPE. Volume 25, Issues 2, pp. 909–919, DOI 10.12694/scpe.v25i2.2606

APPLICATION OF CONTROL ALGORITHM IN THE DESIGN OF AUTOMATIC CRIMPING DEVICE FOR CONNECTING PIPE AND GROUND WIRE

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Abstract. Due to the low effectiveness and poor quality of manual crimping of grounding wires, the author proposes the design of an automatic crimping device for connecting tube grounding wires based on intelligent fully automatic technology. The device consists of a microcontroller, an upper computer control interface, an electric push rod, an infrared sensor, a pressure transmitter, and other devices. The staff used the upper computer monitoring interface to set the relevant parameters for grounding wire crimping, and used X-ray digital imaging technology to measure the crimping size of the grounding wire. The size met the set parameter conditions. Through the PID control algorithm in the microcontroller, the stepper motor was controlled to push the clamp to move, completing the automatic crimping of the grounding wire. The X-ray detection method was introduced to detect the quality of the grounding wire after the crimping was completed. The experimental results show that the average deviation between the measured crimping size of the grounding wire and the actual measurement size by the automatic crimping device is only 0.06 mm, indicating that its measurement results are accurate; The success rate of crimping exceeds 95%. The above experimental results verify that the designed crimping device has high stability and reliability, and good quality detection effect.

Key words: Intelligent fully automatic, Crimping of conductor and ground wire, Device design, Single chip microcomputer, PID control algorithm, Radiographic testing methods

1. Introduction. During the construction of transmission and transformation lines, the construction of grounding wires is a crucial step, and this technology will play a decisive role in the construction quality of the transmission and transformation lines. During the construction of power transmission and transformation lines, it is necessary to inspect and involve the actual situation to ensure the implementation of the grounding wire project and ensure that the project has a certain degree of standardization. At the same time, through focused research and discussion on the construction technology of grounding wires, the specific application of common grounding wire construction technologies is discussed, providing effective references for promoting innovation and reform of transmission and transformation line construction technology, creating a solid foundation for the development of construction technology, and providing conditions for technological innovation [16]. The use of construction technology for grounding wires can effectively improve the operational efficiency of power lines, ensure the safety of construction during the construction of transmission and transformation lines, and reduce construction risks. For the construction technology of the grounding wire, in order to innovate and improve the technology, it is necessary to improve the technical construction based on the natural and geographical environment of the site during construction, pay attention to the quality of the hydraulic connection of the grounding wire, and create an excellent condition for the stable operation of the transmission and transformation lines [20]. At the same time, construction personnel of power transmission and transformation lines should try to avoid the phenomenon of steel anchors or steel pipe damage, which usually occurs during the crimping process. After hydraulic completion, it is necessary to ensure that the connected pipes are within the same size range, which will increase the construction difficulty of the transmission and transformation lines. However, this can ensure the construction quality of the transmission and transformation lines. The two main connection methods of mechanical clamping and hydraulic connection have played a great role in the construction process, ensuring the smooth progress of construction, not only improving efficiency, but also ensuring the quality of construction [1].

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Firstly, the key points of stability. During the construction process of grounding wires, special attention should be paid to the stability of the construction technology. This is because the construction of grounding wires itself belongs to a high standard construction technology, and any link in the construction process is related to the whole. Moreover, construction faults may occur during the actual construction process, and it needs to be judged based on the type of construction technology. Therefore, special attention must be paid to stability during the construction process of the grounding wire project. For example, cracks and deformations are very common in the construction process of hydraulic pliers. This requires construction personnel to adhere to a professional and rigorous work attitude, ensure that all theoretical construction meets the standards and specifications, and strictly review all construction links to ensure the quality of the transmission and transformation lines, in order to ensure the construction quality [8].

Secondly, normative points. In the application process of grounding wire construction technology, it is necessary to be able to fit in with the actual needs of transmission and transformation line engineering. This is because the standardization of grounding wire construction is not fixed, but dynamically changes according to the construction needs of transmission and transformation lines. Therefore, in the construction process of grounding wire engineering, high requirements are put forward for the technical key point of standardization. Generally speaking, regardless of the form of grounding wire construction specifications, the good operation of construction equipment should be ensured, that is, after inspecting and debugging the construction equipment, construction work should be carried out according to the characteristics of the transmission and transformation line construction. After completing the construction work, it is necessary to carefully review the construction results. Once any construction problems are found, timely repairs must be ordered [22].

Thirdly, key points for damage management. During the construction process of power transmission and transformation lines, the grounding wire engineering is easily affected by various factors, resulting in different forms of damage problems. Therefore, during the construction process of the grounding wire project, if any damage problems are found, they must be dealt with according to relevant standards. For example, material deformation, as a common damage problem, if it cannot be dealt with in a timely manner, it may lead to permanent deformation of the material over time, which is extremely detrimental to the smooth progress of transmission and transformation line construction work. Deformation and damage to the steel core aluminum stranded wire are particularly common in the construction of grounding wire engineering. If the damage scale of the steel core aluminum stranded wire has exceeded one fourth of its own, it must be reconnected. If it does not exceed this scale, pressure equipment can be used to correct it.

As a crucial step in the construction process of transmission and transformation lines, the construction of grounding wires has a decisive impact on the quality of construction to some extent. Therefore, in the construction process of transmission and transformation lines, it is necessary to carry out the grounding wire project according to the actual situation, so that the project results are more standardized. In view of this, the following author will focus on exploring the key points of construction technology for grounding wires, and propose the specific applications of common grounding wire construction technologies in the construction of transmission and transformation lines, in order to lay a good foundation for better promoting the development of transmission and transformation line construction.

2. References. For ground wire engineering, hydraulic crimping technology is the most common construction technology. Its main principle is to use hydraulic pumps, pressure piers, oil pipes and other equipment to crimp different types of ground wire materials, thus forming a complete transmission line construction project. The biggest advantage of hydraulic crimping technology is its high stability and relatively low probability of safety accidents. But the disadvantage lies in the strong professionalism of this technology, which requires high-level construction personnel to carry out construction operations smoothly. At the same time, the applicability of this technology is relatively narrow, but because it can be applied to modern grounding wire engineering materials, hydraulic crimping technology has a relatively wide range of applications to some extent. At present, in the construction process of hydraulic pressing technology, the construction focus can be mainly divided into four parts: inspection, cutting, cleaning, and positioning. Among them, inspection refers to the quality inspection of wire clamps and hydraulic equipment before the formal implementation of construction technology, in order to ensure the smooth progress of subsequent construction technology; Cutting refers to the wire cutting work carried out on the premise that the hardware foundation is correct. It should be noted that before carrying out cutting work, priority should be given to confirming the phase and wire type of the wire to ensure that the wire is in a straight state [13]. At the same time, it is strictly prohibited to use oversized pliers and scissors during the cutting process. This is because cutting work often involves cutting to the standard three-quarters position, and the remaining parts need to be manually cut, which requires that the cutting tool should not be too large, otherwise it is easy to have a one-time cutting problem; Cleaning work, as the name suggests, is the cleaning of materials to avoid contamination affecting material quality. It should be noted that gasoline rather than water is required during the cleaning process of the wire material. After cleaning, the material needs to be dried; Positioning mainly involves marking the dimensions on the pressure pipe to form a preliminary positioning for the smooth progress of subsequent crimping work.

The current development of technology has expanded the application scope of intelligent fully automated technology. By utilizing this technology, comprehensive automation of mechanical devices, product processing, and other aspects can be achieved, which not only saves labor, but also improves work efficiency and product quality. Therefore, all industries have entered the era of intelligent fully automated production. Among various control electronic products, single-chip microcontrollers, also known as single chip microcontrollers, are the most powerful. They are composed of multiple logic functional chips integrated together to form a complete system, which can obtain signals from control devices and achieve control of different facilities and equipment through this signal. Microcontrollers have the characteristics of small size, low price, and strong application performance. X-ray digital imaging technology is a new type of non-destructive testing technology that does not cause part loss when detecting parts and has high detection accuracy.

Shindin, E described an effective implementation of a recent simplex type algorithm for precise solutions of discrete continuous linear programming, and compared it with linear programming approximations obtained through time domain discretization for these problems. This implementation overcomes many numerical traps that are often overlooked in theoretical analysis, allowing for better accuracy or acceleration up to several orders of magnitude compared to previous simplex algorithm implementations and state-of-the-art LP solvers that use discretization. Numerical research includes medium-sized, large-scale, and large-scale examples of scheduling problems and fluid processing network control problems. We discussed online and offline optimization settings for various applications and outlined future research directions [11]. Laurini, M consider the finite element approximation of the Bellman equation for optimal control of switched systems. It has been proven that this problem belongs to a special category that we have studied in our previous work, and for this purpose, we have developed an effective solution algorithm. As an application, we propose the problem of generating autonomous vehicle parking strategies in two typical urban parking scenarios. The vehicle is described by four different switching systems, each of which is associated with a penalty term. Through this approach, we obtained a parking path with a small amount of directional changes and a simple structure [5]. The layout design of nuclear power plant pipelines is to find the optimal routing that meets the goals and constraints in the three-dimensional wiring space. However, due to the dense equipment, complex structure, diverse types of pipeline systems, complex layout constraints, and numerous pipelines in nuclear power plants, pipeline layout is a difficult and time-consuming task even for experienced designers. In order to solve the automatic routing problem of pipelines in the three-dimensional wiring space of nuclear power plants, Zhang, J proposed a large space pipeline automatic routing method that combines Dijkstra algorithm with improved algorithm a. Firstly, this method uses the traditional Dijkstra algorithm to identify key vertices in each room of a nuclear power plant, construct a topology routing diagram, and determine the initial channel area of the pipeline. Secondly, divide the space of the layout area into three-dimensional grids, and then identify and preprocess the items in the layout area [19].

Based on the above research background, this article aims to address the quality and efficiency issues in the crimping process of grounding wires. By combining intelligent fully automatic technology and X-ray digital imaging technology, an automatic crimping device for connecting tube grounding wires is designed based on intelligent fully automatic technology, providing a certain basis for improving the level of grounding wire crimping technology.

3. Design of automatic crimping device for connecting tube and ground wire based on intelligent fully automatic technology. This article uses a microcontroller as a controller to design an intelligent fully automatic technology for the automatic crimping device of the connecting tube conductor wire. The

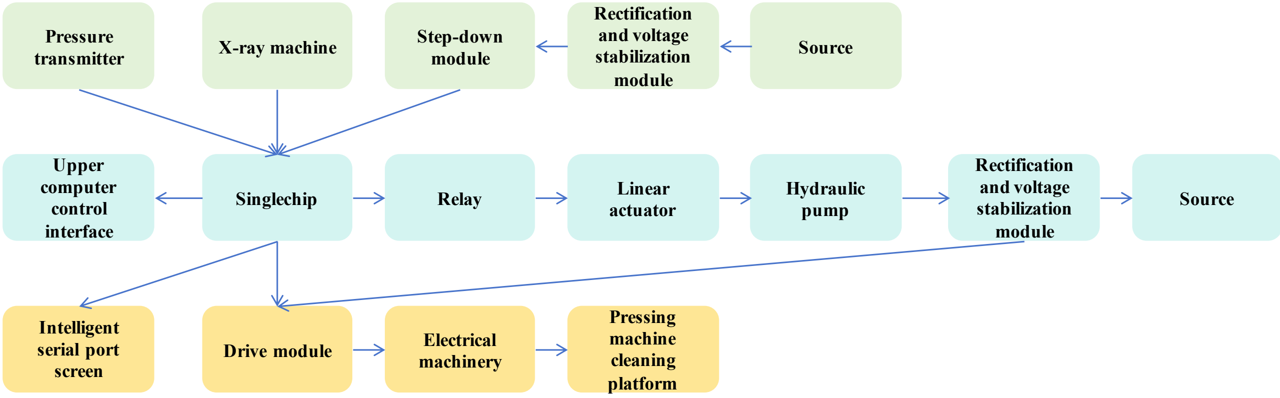

Fig. 3.1: Structure diagram of ground wire automatic crimping device of intelligent automatic technology

automatic crimping device can bear a maximum crimping force of 100MPa, and the measurement accuracy of the conductor wire diameter and movement distance can be accurate to 0.8mm, fully meeting the construction requirements. The automatic crimping device for connecting pipes and ground wires with intelligent fully automatic technology has the advantages of lightweight, simple operation, and ultra-high cost-effectiveness. Figure 3.1 shows the structure of the automatic crimping device for connecting pipes and ground wires using intelligent fully automatic technology [21].

The automatic crimping device for the connecting tube and ground wire of this intelligent fully automatic technology adopts the PCF80C51 series microcontroller from Philips in the Netherlands. This microcontroller has strong data analysis and processing capabilities, can add a large number of breakpoints, and can view memory and registers online, making it easy to operate. The operation process of the microcontroller is as follows: the staff uses the upper computer monitoring interface to set parameters such as the expected diameter and number of movements of the grounding wire after crimping, and transfers the set parameters to the microcontroller controlled by the lower computer controller. The microcontroller controls the stepper motor to push the clamp installed on the pulley to move. When the speed of the stepper motor and the movement of the pulley reach the set parameters, the automatic crimping process of the grounding wire begins. At this time, the changes in the automatic crimping value of the grounding wire are displayed to the staff through the upper computer monitoring interface.

3.1. Measurement of conductor crimping size based on X-ray digital imaging. During the automatic crimping process of the grounding wire, there may be some errors in the actual size of the grounding wire crimping due to operational factors by the operator. To avoid the occurrence of crimping errors in the grounding wire, it is necessary to study the correlation between the crimping size of the steel core and the tension of the grounding wire, and accurately measure the actual crimping size of the steel core. After years of development, X-ray digital imaging technology has transformed from simple film radiographic inspection to advanced digital technology, and the detection accuracy is becoming increasingly high. This article uses X-ray digital imaging technology to measure the size of ground wire crimping. This technology consists of digital imaging, image processing, auxiliary facilities, etc. The actual size of the steel core pressed into the steel anchor is obtained by transforming the position and size measurement software of the ground wire, and accurate positioning of the automatic crimping size of the ground wire can be achieved without damaging the ground wire [2]. The specific measurement principle of the crimping size of the grounding wire is shown in Figure 3.2.

3.2. Automatic crimping control of conductor and ground wire.

3.2.1. Crimping pressure control principle. The pressure of the medium voltage clamp during the automatic crimping process of the grounding wire will directly affect the final effect of the automatic crimping of the grounding wire. Therefore, a pressure detection system is used to accurately measure the pressure of

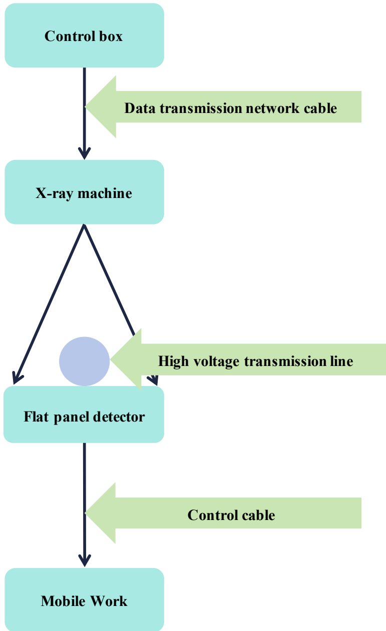

Fig. 3.2: Principle of guide ground ground size measurement of X-ray digital imaging technology

the medium voltage clamp during the crimping process of the grounding wire. The automatic crimping device for the connecting pipe and ground wire of intelligent fully automatic technology outputs liquid oil through the infusion pump driving the crimping pliers. The liquid pressure is detected by a pressure transmitter. To prevent sediment deposition, the pressure tap is set on the side of the process pipeline [7], and the pressure transmitter is set on the edge of the pressure tap.

Set the Wheatstone bridge on the diffusion silicon chip inside the pressure transmitter. When the measured liquid is pressurized, the bridge wall resistance value produces a piezoresistive effect, generating a differential voltage signal [17]. Use an internal dedicated amplifier to convert the signal corresponding to the range into an analog voltage signal , and use the I/O pins of the microcontroller to input the analog voltage signal into the microcontroller. After data processing, output the monitoring results. The automatic crimping device for connecting pipes and ground wires using intelligent fully automatic technology consists of a hydraulic pump, crimping pliers, electric push rods, etc. The hydraulic pump switch is used to control the electric push rod, and the hydraulic pump is connected to the crimping pliers. When the grounding wire reaches the set position, the microcontroller controls the electric push rod to start the hydraulic pump. When the pressure reaches the set value, it starts to press and hold for a certain period of time. Then, the grounding wire is moved to another designated position for a second press, and the above process is repeated to complete the automatic crimping of the grounding wire. The principle of crimping pressure control is shown in Figure 3.3.

3.2.2. Control algorithm design. Introducing PID control algorithm in the stepper motor control stage of the microcontroller program can accurately control the movement of the crimped grounding wire. The PID control algorithm can analyze the deviation of the measured value of the ground wire movement and output a certain value to achieve ground wire crimping control [14]. Assuming that the deviation between the actual output value and the theoretical output value is represented by $u(t)$, the calculation formula for this deviation is as follows:

$$u(t) = r(t) - b(t) \tag{3.1}$$

Among them, $r(t)$ and $b(t)$ respectively represent the set value of the stepper motor speed and the actual measured value of the stepper motor speed.

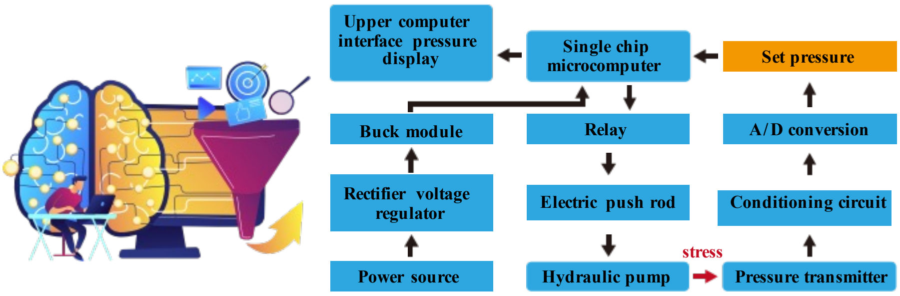

Fig. 3.3: Schematic diagram of the crimp pressure control

Calculate the proportion, integral gain, and differential gain generated by the set value and output value using a linear combination method to achieve microcontroller control. The control calculation formula is as follows:

$$u(t) = K_p \left[u(t) + \frac{1}{Y_I} \int_0^t u(t)dt + \frac{TDdu(t)}{dt} \right] \tag{3.2}$$

The transfer function form of formula (3.2) after sorting is as follows:

$$G(s) = \frac{U(s)}{E(s)} = K_p \left(1 + \frac{1}{Y_I s} + Y_D s \right) \tag{3.3}$$

where K_p represents the proportion; Y_I represents the integral gain; Y_D represents differential gain.

To achieve microcontroller control, formula (3.2) needs to be converted into a differential equation, and its calculation formula is as follows:

$$\int_0^t u(t)dt \approx \sum_i^k Y u(i) \tag{3.4}$$

$$\frac{du(t)}{d(t)} \approx \frac{u(k) - u(k-1)}{Y} \tag{3.5}$$

The PID control calculation formula can be obtained through formulas (3.2), (3.4), and (3.5), as follows:

$$u(k) = K_p \left[u(k) + \frac{Y}{Y_I} \sum_{i=0}^k e(i) + Y_D \frac{u(k) - u(k-1)}{Y} \right] \tag{3.6}$$

3.3. Quality inspection of grounding wire crimping. During the automatic crimping of the grounding wire, there may be wire drops, resulting in quality issues in the crimping of the grounding wire. This article uses a radiographic testing method to detect wire drops during the automatic crimping process of the grounding wire. The radiographic testing method can clearly identify the crimping status of the grounding wire through image processing, and will not cause loss of the grounding wire during the testing process, saving costs [6].

When a ray passes through a conductive wire, the intensity of the ray is closely related to the density and thickness of the conductive wire. The formula for calculating the attenuation law of radiation is as follows:

$$P = P_0 e^{-\mu x} \tag{3.7}$$

Among them, P, P_0, x, and μ respectively represent the intensity of the ray after passing through the ground wire, the initial intensity of the incoming ray, the thickness of the ground wire, and the attenuation coefficient of the object.

Table 4.1: Specific parameters of the X-ray machine

Form	Category	Parameter
5*X-ray generator	Radiation source voltage	60∼160 kV
	Ray source current	0.2∼3 mA
	Focus size	0.4 mm
	2*Maximum penetration force	AL: 100 mm
		PE:20 mm
4*Imaging detector	Radiation source power	300 W
	Imaging size	150 mm × 120 mm
	Pixel size	85 μm
	resolving power	58 Lp/ cm

The initial intensity of the incoming ray can be calculated using formula (3.7). When the ray passes through a gap of size, the intensity calculation formula is as follows:

$$P = P_0 e^{-\mu(x-\delta)} \tag{3.8}$$

where δ represents the size of the gap between the conductor and ground wire. Based on the basic law of ray attenuation and the properties of exponential functions, the formula for the intensity of rays projected through various homogeneous materials can be obtained, as follows:

$$P = P_0 e^{-(\mu_1 x_1 + \mu_2 x_2 + \mu_3 x_3 + \ldots \mu_N x_N)} \tag{3.9}$$

Among them, x_N and μ_N respectively represent the penetration thickness and attenuation coefficient of different objects [4].

During the detection process of the grounding wire, when the steel strand does not fully enter the steel pipe, the ray penetration thickness is the thickness of the aluminum pipe plus the thickness of the steel pipe, which is $x_{\text{Aluminum tube}} + x_{\text{Steel pipe}}$. When the steel strand fully enters the steel pipe, the ray penetration thickness is the thickness of the aluminum pipe plus the thickness of the steel pipe plus the thickness of the steel strand, which is $x_{\text{Aluminum tube}} + x_{\text{Steel pipe}} + x_{\text{Steel strand}}$. By comparing the ray penetration thickness when the steel strand does not fully enter the steel pipe and when it fully enters the steel pipe, and substituting the comparison results into formula (3.9), there is:

$$\begin{aligned}\frac{P_1}{P_2} &= \frac{P_0 e^{-(\mu_{\text{aluminium}} x_{\text{Aluminum tube}} + \mu_{\text{steel}} x_{\text{steel pipe}} + \mu_{\text{steel}} x_{\text{steel strand}})}}{P_0 e^{-(\mu_{\text{aluminium}} x_{\text{Aluminum tube}} + \mu_{\text{steel}} x_{\text{steel pipe}})}} \\ &= e^{-\mu_{\text{steel}} x_{\text{steel strand}}}\end{aligned} \tag{3.10}$$

Among them, P_1 and P_2 respectively represent the thickness of ray penetration when the steel strand does not fully enter the steel pipe and when it fully enters the steel pipe.

By comparing the radiation intensity at different times, the quality inspection of grounding wire crimping is achieved [12].

4. Experimental analysis. The model of the connecting tube grounding wire in this experiment is BLV450/750V, and the cross-section of the grounding wire is 5-35mm2. 1000 grounding wires are divided into 10 groups for every 100 wires. The steel core is automatically crimped at both ends of the grounding wire with a steel anchor size of 0-60mm, and the other end of the grounding wire with a steel anchor size of 70-100mm is automatically crimped. The manufacturer of the X-ray machine used in the experiment is Ruiao Testing Equipment (Dongguan) Co., Ltd., with the model RAYON-RE2100. The specific parameters are shown in Table 4.1 [10].

The accuracy of the crimping size of the grounding wire affects the crimping results. 10 sets of crimping sizes of the grounding wire were measured using the device described in this article, the traditional method 1

Table 4.2: Measurement results of ground ground (mm)

Group	Traditional method 1 device	Traditional method 2 device	The device	Actual measurement value
1	1.06	1.03	1.18	1.18
2	2.22	2.14	2.34	2.34
3	1.99	1.83	2.13	2.14
4	0.86	0.91	1.01	1.08
5	0.85	0.57	0.92	0.99
6	1.33	1.34	1.33	1.49
7	1.97	2.17	2.11	2.27
8	0.97	1.06	1.36	1.37
9	0.57	0.86	0.79	0.87
10	1.24	1.55	1.66	1.71
Average Discrepancy	0.24	0.20	0.06	/

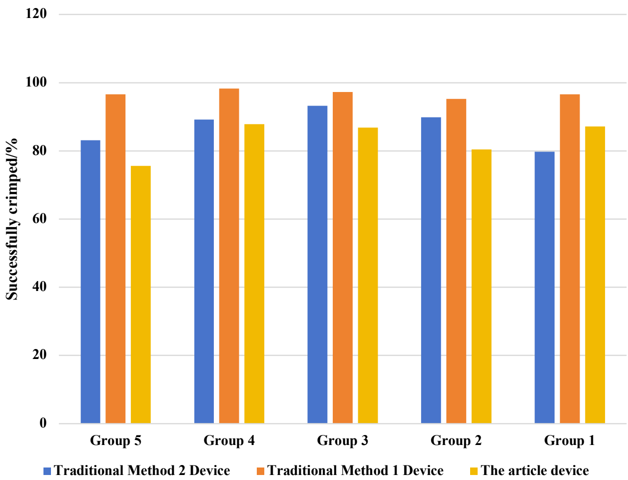

Fig. 4.1: Ground wire crimping results of three crimping devices

device, and the traditional method 2 device. The results are shown in Table 4.2, where traditional method 1 represents an electric drive hydraulic large-section grounding wire crimping device, and traditional method 2 represents a cable joint crimping device based on electromagnetic pulse forming technology.

According to Table 4.2, there is a certain deviation between the crimping dimensions of the grounding wires measured by the three devices and the actual measurement dimensions. Among them, the average deviation values of the 10 sets of measurement results for the traditional method 1 device and the traditional method 2 device are 0.24mm and 0.20mm, respectively. The difference between the crimping size of the grounding wire measured by the device and the actual measurement size is not significant, with an average measurement deviation of only 0.06mm, indicating that the device has high accuracy in the crimping measurement of the grounding wire [3].

Select 5 sets of grounding wires and use three crimping devices to crimp them, and verify the crimping results of the grounding wires. The results are shown in Figure 4.1.

Analyzing Figure 4.1, it can be seen that among the 5 sets of grounding wire crimping results, the success rate of traditional method 1 device grounding wire crimping is between 75% to 90%, and the success rate of traditional method 2 device grounding wire crimping is between 80% to 95%. The success rate of crimping the grounding wire of the device in this article is above 95%, and close to 100%. Compared with the traditional

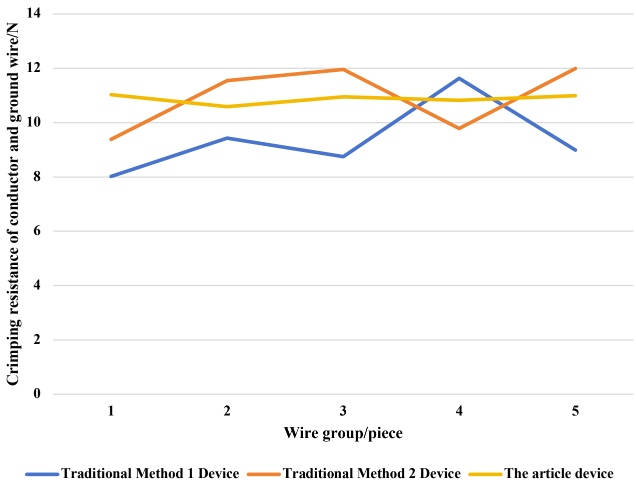

Fig. 4.2: Guide ground wire tensile test results

method 1 device and the traditional method 2 device, the device in this article has higher results in crimping the grounding wire [18, 9, 15].

During the automatic crimping process of the grounding wire, the crimping device must have high reliability and stability. Five sets of grounding wires are selected, and the crimping force is set to 11N. The information on the tension of the grounding wire during the crimping process is integrated, and the reliability and stability of the three crimping devices are analyzed. The results are shown in Figure 4.2.

Analyzing Figure 4.2, it can be seen that the tensile strength of the ground wire crimped by the traditional method 1 device and the traditional method 2 device differ significantly from the set tensile strength value. Among them, the maximum difference between the tensile strength of the ground wire crimped by the traditional method 1 device and the set tensile strength is 2N. Although there is some fluctuation in the tensile resistance value of the crimped grounding wire in the device, it is closest to the set tensile resistance value. Therefore, it can be concluded that the device has high reliability and stability.

Using sensitivity as a measure of the actual application performance of crimping devices, calculate the sensitivity of three crimping devices during the automatic crimping process of grounding wires, as shown in Figure 4.3.

Analyzing Figure 4.3, it can be seen that when the cross-sectional area of the grounding wire is different, the sensitivity of the device in this paper remains above 0.9, and the highest sensitivity reaches 0.98. The sensitivity of the traditional method 1 device and the traditional method 2 device varies from high to low, with the highest sensitivities of 0.92 and 0.88, respectively, which are significantly different from the sensitivity of the device in this paper. Therefore, it can be concluded that the sensitivity of the device in this paper is high and its practical performance is strong.

The inspection of the crimping quality of the grounding wire is an important step to ensure the quality of the grounding wire after crimping. The accuracy of the quality inspection of the grounding wire for three crimping devices is tested, and the results are shown in Figure 4.4.

Analyzing Figure 4.4, it can be seen that as the number of grounding wires increases, the detection accuracy curves of the traditional method 1 device and the traditional method 2 device show a downward trend. However, the detection accuracy curve of the device in this article is relatively smooth and the accuracy rate remains around 95%, indicating a high quality detection accuracy rate for grounding wires.

5. Conclusion. This article uses microcontroller and X-ray digital imaging technology to design an automatic crimping device for connecting tube conductors based on intelligent fully automatic technology. The microcontroller has powerful functions in data transmission, setting, clearing, testing, etc. It can not only handle any bit of special function registers but also perform logical operations on the bit. The device uses a

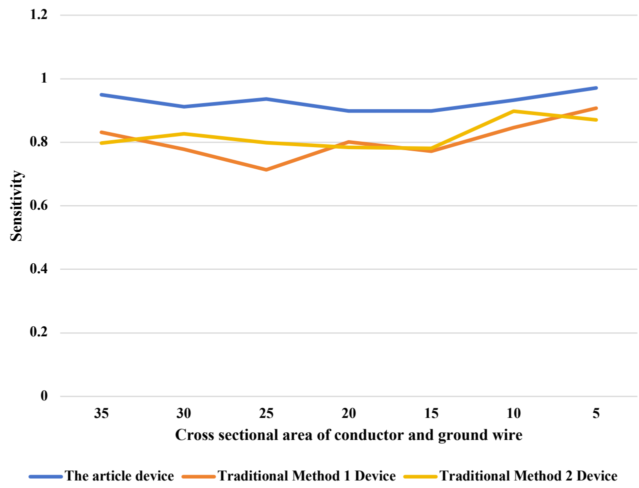

Fig. 4.3: Ground wire sensitivity of the three crimping devices

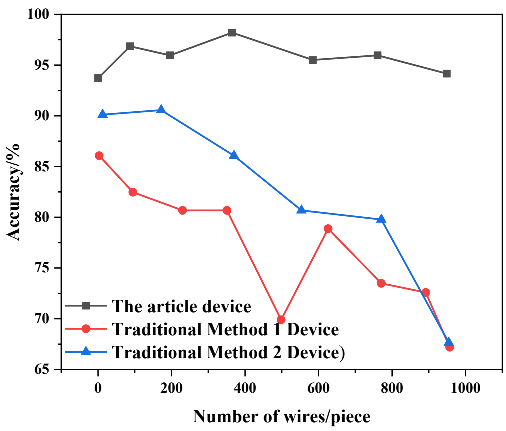

Fig. 4.4: Ground wire quality test results of the three crimping devices

microcontroller as a controller to achieve automatic crimping of the grounding wire. After experimental verification, it has been found that the difference between the measured crimping size of the grounding wire and the actual measurement size is small, with an average deviation of only 0.06mm; The success rate of crimping is above 95%, and the crimping results of conductor and ground wire are relatively high; The difference between the tensile strength and the set tensile strength of the crimped conductor wire is small, which has high reliability and stability; The highest sensitivity of the crimping device reaches 0.98, indicating a high sensitivity; The accuracy curve of ground wire quality detection is relatively smooth and the accuracy rate is maintained at around 95%.

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Edited by: B. Nagaraj M.E.
Special issue on: Deep Learning-Based Advanced Research Trends in Scalable Computing
Received: Sep 13, 2023
Accepted: Nov 4, 2023