Research on the Automatic Stripping Technology of Cable Sheath and Shield Layer Assisted by Multi-Sensor System

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Abstract: This paper aims to improve the precision and efficiency of cable sheath and shield layer stripping by integrating multi-sensor systems. The proposed system combines optical, temperature, and pressure sensors to monitor and control key parameters in the stripping process. Optical sensors are used to track the relative position of the cable and tool, while temperature sensors monitor the heat generated during stripping to prevent overheating. Pressure sensors ensure proper clamping force, maintaining cable stability during stripping. Experimental results show that the proposed method significantly improves stripping accuracy, reduces tool wear, and enhances production efficiency compared to traditional manual methods. The originality of this work lies in the integration of multiple sensors to optimize the stripping process in real-time, which leads to higher accuracy and longer tool lifespan.

Keywords: Multi-Sensor System; Cable Stripping; Automation; Optical Sensing; Temperature Monitoring; Pressure Control

1. Introduction

As an important part of modern power, communication and automation system, the quality of cable directly affects the stability and reliability of the whole system. The stripping of cable cover and shielding layer [1] is an important process step in cable processing, and its accuracy is directly related to the quality of subsequent welding, joint and other processes. The traditional cable stripping method mainly relies on manual or single mechanized equipment, stripping accuracy and efficiency is low, and easy to cause damage to the tool, leading to the increase of processing cost. In recent years, with the rapid development of automation technology and sensor technology, the multi-sensor assisted automatic stripping technology [2] has become an effective means to improve the accuracy and efficiency of stripping.

Combined with optical sensor, temperature sensor and pressure sensor [3], this paper proposes a multi-sensor assisted automatic stripping technology of cable shield and shielding layer. Through real-time monitoring and adjustment of the key parameters in the stripping process, the stripping accuracy is improved, the tool wear is reduced, and the production efficiency is improved. The experimental results verify the feasibility and advantages of this technology, and provide new ideas for the development of cable stripping technology.

2. Multi-Sensor System Design

2.1 Optical Sensor

Optical sensor is one of the core components of this system, which is mainly used to detect the relative position change between the cable and the tool in real time. In order to ensure the high precision of the stripping process, the high-precision laser displacement sensor (such as JGWY 6 series) is selected. As shown in Figure 1, the sensor has the advantages of non-contact measurement, high response speed and strong stability, [4]. The laser sensor can monitor the distance between the cable surface and the tool in real time, and adjust the tool feed depth through the feedback signal.

Figure 1. Appearance of the Laser Sensor

The application of the laser sensor in the stripping process can effectively avoid the uncertainty caused by contact between the cutting tool and the cable, improving the precision and stability of the stripping process. The system uses the distance signal feedback from the laser sensor to precisely control the cutting depth of the tool, ensuring that each stripping meets the predetermined standards.

2.2 Temperature Sensor

During cable stripping, high heat is usually generated due to the friction between the tool and the cable cover. Excessive temperature can not only affect the performance of the cable material, but also may cause premature wear of the tool. Therefore, temperature control is a key factor to ensure the stripping accuracy and tool life. The thin film thermocouple and thermosensitive ceramic sensor [5], as shown in Figure 2, showed excellent performance in laboratory accurate measurements and industrial applications.

Figure 2. Intelligent Ceramic Cutting Tool for Temperature Monitoring

2.3 Pressure Sensor

To ensure that the cable is stably clamped during stripping, the pressure sensor is used to monitor the grip force [6] in real time. The system feeds back the clamp pressure in real-time through the resistive pressure sensor to ensure that the cable is not offset or damaged during stripping. The sensor has high sensitivity and is suitable for high precision industrial detection.

By adjusting the strength of the claw, the system can ensure the stability of the cable, so as to avoid the cable scratches or incomplete stripping caused by uneven pressure. The control system accurately controls the clamping force according to the real-time data feedback by the pressure sensor, so that the cable can remain stable during the whole stripping process.

3. Automatic Stripping Process Flow

Combined with the wire stripping process, the automatic wire stripping device designed in this paper includes execution part, driving part, sensing part, power part, power part, control system, handheld operating system, digital acquisition system and video monitoring. The composition diagram is shown in Figure 3. The control system has Siemens 1200 series [7] PLC as the main controller, and the data acquisition system is mainly industrial controller, together with handheld touch screen and field servo motor composed of Profinet bus and Ethernet network. The schematic diagram of the control system in the form of communication.

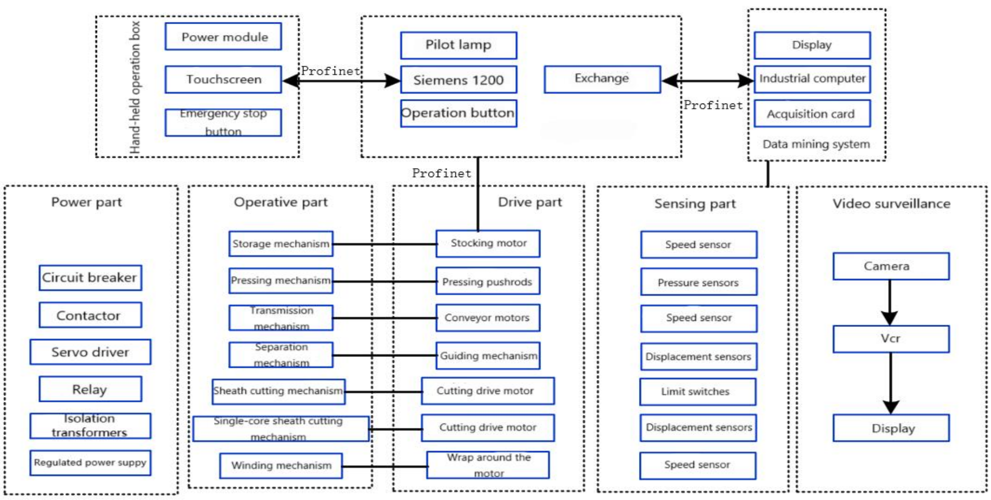

Figure 3. Process Flow Diagram

The first step of the stripping process is the positioning and fixation of the cable to ensure that the cable does not offset during the stripping process. The system detects the position of the cable through the visual sensor and adjusts the clamping force through the pressure sensor to ensure that the cable is firmly fixed in the working position.

During the stripping process, the optical sensor monitors the input depth of the tool in real time, and adjusts the input speed and depth of the tool according to the feedback signal of the sensor. The temperature sensor monitors the operating temperature of the tool to prevent overheating; the pressure sensor ensures the clamping force stability to avoid the quality problems caused by improper cable clamping.

After the stripping is completed, the cable will enter the quality inspection link. The system uses visual sensors to detect the stripped cables to ensure that the stripped quality meets the requirements. Through the image recognition technology [8], the system can detect whether there are problems such as uneven stripping or residual protective layer, and timely adjust or mark the unqualified products. As shown in Figure 4, the system is clearly structured and tightly connected, ensuring an effective collaboration among the various components.

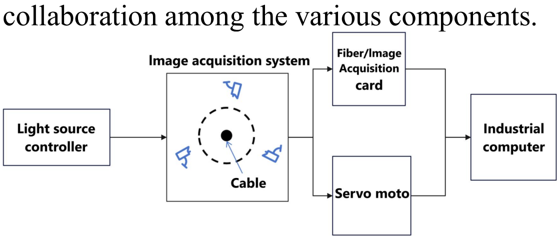

Figure 4. Overall Structure of Cable Surface Defects

4. System Architecture and Data Processing

The system consists of PLC controller, sensor module, actuator and human-computer interaction interface. The PLC controller communicates with various sensors and controls the motor, claw clamp and other actuators to complete the automatic stripping task. Data acquisition and processing are realized through industrial control machine and data acquisition card to ensure the real-time performance and stability of data transmission.

As shown in Figure 5, the system adopts a hybrid control strategy combining PID control and fuzzy control [9] to optimize the various key parameters in the stripping process. The PID control algorithm responds quickly to ensure the real-time adjustment of the blade depth, tool temperature and clamping strength; the fuzzy control can handle the complex uncertainty and nonlinear relationship [10] to improve the adaptability and robustness of the system.

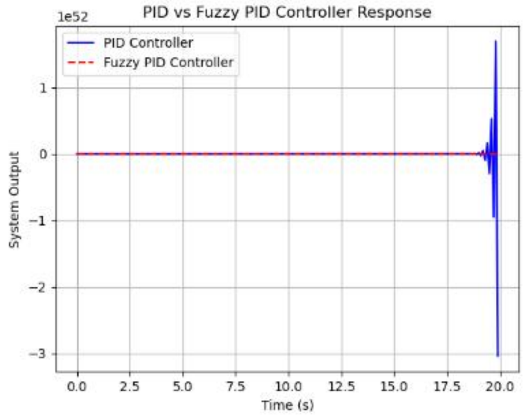

Figure 5. PID Algorithm after Optimization with Fuzzy Control Introduced

5. Experiments and Result Analysis

To verify the feasibility of the proposed technology, this paper set up an experimental platform and conducted multiple cable stripping experiments. In the experiments, we set different types of cables such as single-core cables, multi-core cables) and different cutting tool parameters, and adjusted the control strategy based on experimental data. The experimental results show that the automatic stripping system based on multi-sensor assistance can significantly improve stripping precision, reduce tool wear, and improve production efficiency. Compared with traditional manual stripping methods, the stripping precision and efficiency of the proposed system have increased by more than 20% and 30%, respectively, and the service life of the cutting tools has been extended by about 15%.

6. Conclusion

The automatic cable sheath and shielding layer stripping technology based on multi-sensor assistance proposed in this paper integrates optical, temperature, and pressure sensors to precisely control key parameters during the cable stripping process. Through experiments, this technology has shown significant advantages in improving stripping precision, reducing tool wear, and enhancing production efficiency. In the future, with the further development of artificial intelligence and big data technologies, the system's adaptive capability and intelligence level will be greatly enhanced, providing stronger support for the automation of the cable processing field.

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