Automatic raw material screening device for wind turbine foundation anchor bolt

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ABSTRACT

With excellent development prospects, wind power generation is one of the most important parts of new energy. Because it has a lot of advantages over traditional energy forms energy, such as availability, free pollution and renewability, etc, many researchers of different countries have concentrated on such field. As an important part of fan foundation, anchor bolt assembly realizes the transfer and dispersion of complex loads such as horizontal load, bending moment and torsion of wind turbine through anchoring, self-locking and synergistic action with concrete. In order to further promote the application of wind power generation, the cost reduction of equipment production involved in this field has attracted extensive attention; therefore, the automatic production of anchor bolt assembly has also become an important research direction in the production field. In the traditional production process of wind turbine foundation anchor bolt, manual screening method is adopted in this paper, and there is only one specification (diameter and length) of anchor bolt raw material on a production line at the same time. In this case, the efficiency of multi-task processing in the production line will be greatly reduced. Therefore, it is extremely important to develop control equipment that can realize automatic raw material screening and distribution.

Keywords: Bar screening, task assignment, length measurement

1. INTRODUCTION

In order to improve the screening efficiency, automatic bar screening should be completed in the transportation line of anchor raw materials, that is, the screening of anchor raw materials is completed during the movement of anchor raw materials. Because the anchor raw materials transmission is mostly completed by the V-wheel driven by the motor, there are multiple vibration sources [1] in the transmission process of the bolt raw material in the production line, such as motor vibration and uneven transmission line, resulting in vibration or slight jump of the bolt in the transmission process, which brings difficulties to the length measurement [2]. At the same time, in order to meet the needs of multi-task processing, the controller should have accurate length screening and task allocation functions.

The existing automatic bar screening usually adopts timing, grating length measurement and laser radar length measurement scheme [3]. Due to the vibration, motor speed change and other factors in the transmission process of anchor raw materials, the speed of raw materials is not constant, so the length measurement error is large. The accuracy of grating length measurement scheme is high, but due to the length range of anchor raw materials is usually between 3000 mm and 6000 mm, the measurement range of grating length measurement scheme is relatively short, which can not meet the existing needs. The laser radar length measurement scheme has high accuracy and fast measurement speed [4], but it is difficult to be applied to the automatic anchor selection process because of the vibration in the anchor transmission process and the high cost of such scheme. In addition, since there are usually multiple machine tools in the same production line, the controller should have intelligent task allocation function when different machine tools deal with different specifications of anchor raw materials and some machine tools deal with the same specifications of anchor raw materials， which most of the same type of controller lack such function [5].

The article presents a novel method and programme of automatic bar screening, as well as conclusions and the directions of further development.

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2. FUNCTION ANALYSIS

The raw material screening controller of wind turbine foundation bolt is divided into two functional modules according to the function, which is convenient for the design, debugging and realization of the equipment. Functional block diagram as shown in Figure 1, the primary function of the raw material screening controller is the screening function, the core of which is the accurate length measurement of the bar in the movement process. In addition, to improve the accuracy of bar length measurement, the controller adopts the method of "length calibration of standard bar", that is, before daily raw material processing, according to the command of the central computer, the controller will measure the length of a 4-meters-long standard bar and obtain the measurement error of the standard bar as the correction basis of the measurement result of the day. The controller will control the actuators to carry out corresponding operation accord to the measurement and task distribution results. The functional modules of data interaction mainly realizes the following three purposes: the central control computer can ,in accordance with the production needs of the line, configure the operation parameters of any the raw material screening controller at any time, such as screening target length of the bar and equipment operation status ; secondly, the controller can upload the operation data [6] in real time, including the operation status and fault information, etc, so as to realize the real-time monitoring of the equipment operation status by the central control computer; furthermore, data sharing is realized between equipments through data interaction, including equipment status, configuration parameters and processing time of remaining raw materials to be processed, and the rational allocation of processing tasks is completed, so as to improve processing efficiency and equipment utilization.

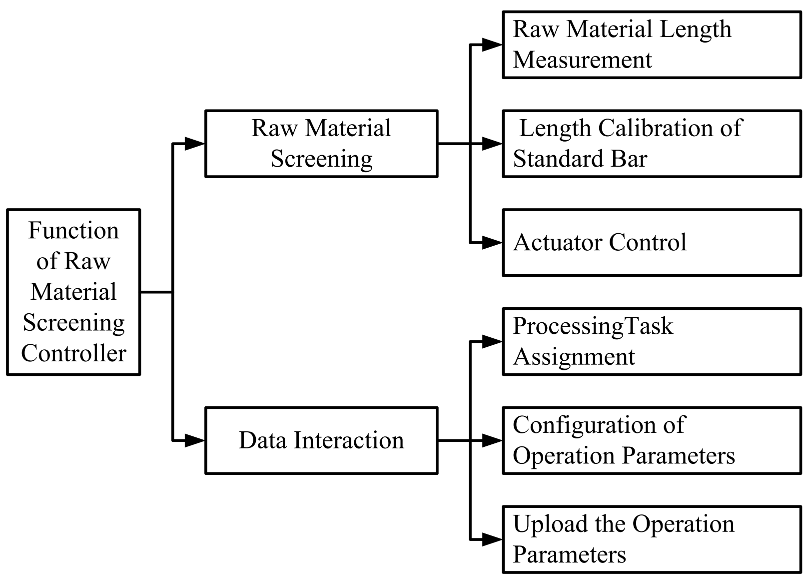

Figure 1. Functional block diagram.

3. HARDWARE DESIGN

3.1 The core of control system

The existing PLC controller has stable performance, but in view of its high cost, in order to further reduce the cost of the controller, the controller uses STM32 series controller as the control core, and STM32F103VBT6 microcontroller is used as the core controller in this design. STM32F103VBT6 has rich and configurable IO interfaces and stable communication interfaces, and adopts stable peripheral circuits and electromagnetic compatibility design to improve the reliability of the equipment, which can fully meet the design needs.

3.2 Bar length measurement module

The length measurement module adopts the combination of two photoelectric switches and a rotary encoder [7] to realize the length measurement in the transmission process. The model of the two photoelectric switches is E3Z-T61, and the model of the rotary encoder is E6B2-CWZ6C. Physical drawing of bar length measuring device is shown in Figure 2.

The encoder wheel has a circumference of 250 mm, and the encoder outputs 1000 pulses every circle the wheel rotates, so the length measurement resolution of 0.25 mm. The encoder wheel is located below the bar to be tested, and the encoder bracket contains a spring mechanism to ensure that the wheel can be closely attached to the bar surface during the movement of the bar.

The moving speed of the bar is about 850 mm per second. The first photoelectric switch is located at 100mm in front of the rotary encoder. When the photoelectric switch continuously detects an object for more than 50 ms, it will enable and reset the pulse counter in the controller to prevent the counting error caused by the idling of the code wheel during the vibration of the equipment. The second photoelectric switch is positioned right above the code wheel, the detection point is positioned at the radial center of the bar, the detection result of the photoelectric switch is calculated by a gate circuit and a rotary encoder, and the "and" result is transmitted to a pulse counting interface of a Microcontroller unit. The detection result of the second photoelectric switch is used as a counting enable, so that invalid pulses are shielded, and the purpose of further improving the measurement accuracy is achieved.

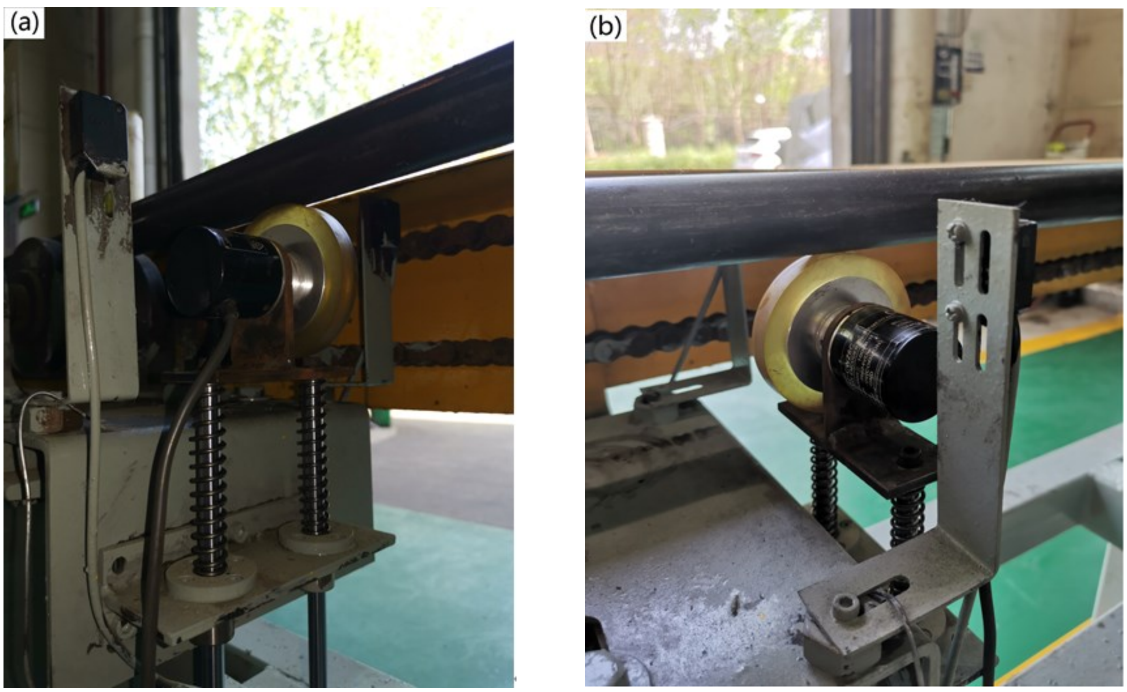

Figure 2. Bar length measuring device.

3.3 Communication interface

In this design, CAN-bus is used to form a communication network to realize the interaction of data between devices. The CAN-bus protocol has a strong error correction mechanism, which can realize the error-free transmission of data. Each sub-module can be given an ID value according to the type and number of the equipment. The system can support 2048 nodes at most, so the whole network has strong flexibility and scalability. In this design, TJA1050 high-speed CAN-bus transceiver is used as the interface chip, and peripheral auxiliary protection circuit is used to improve the stability and reliability of the controller as much as possible.

4. SOFTWARE DESIGN

After analyzing the popular software in such field, the software is divided into three parts in accordance with function. The three parts are data interaction and operation module, raw material screening module and processing task assignment module. The Program flow chart of the control software is shown in Figure 3.

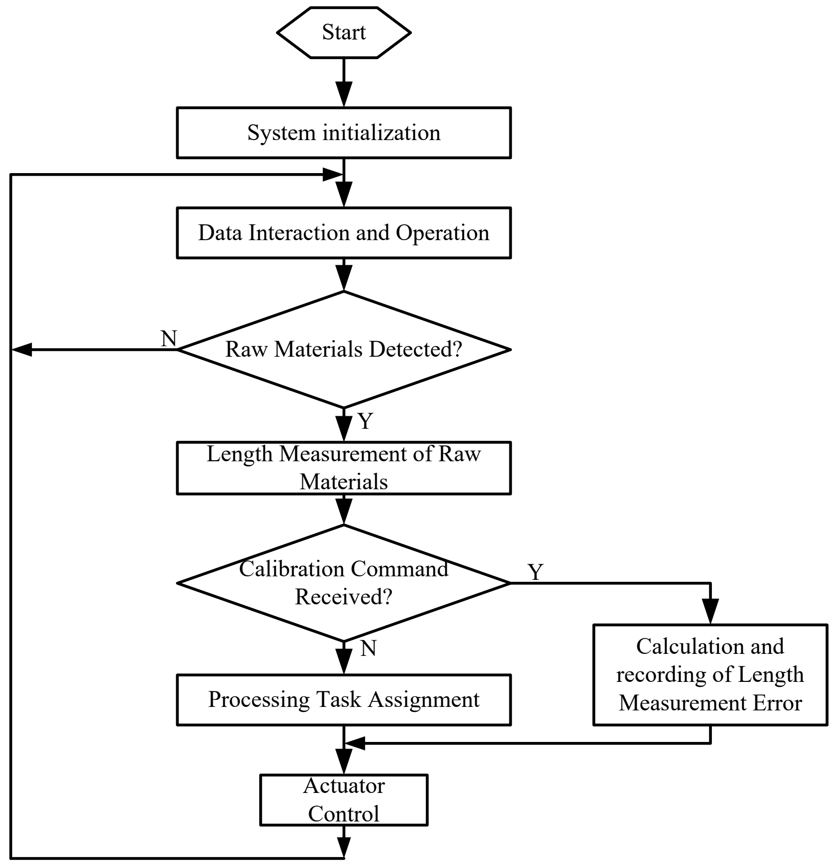

Figure 3. Program flow chart.

After the controller starts, it will first read the equipment operation configuration parameters in the external memory, such as target length and correction basis of the measurement result, and initialize the hardware of the equipment, including IO port initialization and communication parameter initialization. In terms of data interaction, on the one hand, the controller will upload operating parameters to the central control computer and other equipment at fixed time intervals or the time when the operating parameters of the equipment change, such as the processing time, target length and operating status of the actuator of the remaining raw materials to be processed in the current equipment pool; On the other hand, the controller receives the operating parameters of other similar controllers and the parameter configuration commands sent by the central control computer, and performs corresponding operations [8]. When the controller receives the calibration command, it executes the length measurement of the standard raw material with a specific length, and records the measurement error as the calibration compensation for the subsequent length measurement operation [9]. In that normal work state, the equipment measures the length of the raw material, and aft calibration and compensation, if the length is the target length of the controller, the raw material is used as a material to be selected, otherwise, the raw material is not screened; At the same time, the controller compares tasks with other controllers (with the same target length) [10]. If the processing time of the remaining raw materials to be processed in the current equipment pool is the shortest, the raw materials will be screened.

5. CONCLUSION

The automatic bar screening equipment can complete the accurate measurement of the length of the bar raw material in the process of movement, with a measurement accuracy of 1.8 mm; at the same time, due to the smart task allocation function of the equipment, the efficiency of the entire production line and the utilization rate of equipment are greatly improved, thus reducing the processing cost of raw materials to a certain extent.

In this paper, a novel design programme of wind turbine foundation anchor bolt raw material screening equipment is proposed. Compared with other similar designs, this design scheme has the following advantages:

(1) In terms of screening speed and efficiency, the manual screening scheme requires raw materials to be completed in a static state, while the length measurement of the anchor bolt in the scheme is completed in a moving state, so the screening speed and efficiency are greatly improved;

(2) In terms of measurement accuracy, compared with other automatic screening schemes, the measurement accuracy is improved by 273% due to the use of "photoelectric switch & rotary encoder" and "correction compensation" schemes;

The design scheme has been put into use in several wind turbine foundation anchor bolt production lines, and the test and use results show that the equipment has perfect functions and excellent performance. At the same time, because of its distributed control system design concept, the system has strong scalability, and can be used in other bar and plate raw material screening field.

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