Servo control and detection system of magnetic levitation pipeline based on FPI bus

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Abstract: The growth rate of China’s plastic pipe industry ranks first in the world. In 2018, China’s plastic pipe production broke through the 16 million ton mark. With the growth of China’s economy, the output of plastic pipe still has a large space for increase. However, the detection of pipeline defects has been relatively backward in China. Aiming at the problem of pipeline internal inspection, this paper proposes a magnetic suspension non-contact detection method, and designs a real-time feedback servo control system for the detection system, to improve the efficiency and quality of pipeline inspection, and expand the scope of pipeline inspection in industrial production.

1. Introduction

PE pipeline is an important branch of many components of engineering building materials, which is an important factor related to the development of national economy. It plays an important role in engineering construction, water conservancy construction, urban construction and rural construction. Aiming at the diameter, roundness and defect detection items inside and outside the pipeline, this paper innovatively designs the detection method and the corresponding detection system based on the suspended magnetic block.

2. Design of magnetic levitation detection platform

The pushdown maglev device mainly relies on the mutual repulsion between the magnetic fields, and uses the repulsion between the permanent magnets to offset the gravity of the suspension. In this way, the coil consumes less electric energy and generates less heat. In the horizontal direction, the pushdown maglev device can fine tune the suspension by setting the electromagnetic coil, the coil current is small, and the heat generated by the coil is not high. Due to the repulsive force between the permanent magnets, this kind of support has strong anti-interference ability. At the same time, the pull-down maglev device only needs to set the permanent magnet and the corresponding electromagnetic coil at the bottom, which can meet the limited space demand of pipeline production.

Therefore, this paper decided to use the pushdown Maglev Platform, that is, the repulsive force between permanent magnet and permanent maglev body with constant magnetic field is used to provide the levitation force, and the horizontal interaction force between electromagnet and suspension body controlled by linear Hall sensor is used to provide the control force for stable control. The float is equipped with a depth camera and corresponding circuit to detect the inside of the pipeline. The wireless charging receiving circuit provides power for the depth camera and its circuit to realize continuous operation. The magnetic suspension detection platform is shown in Figure 1 below.
3. Detection system design

In order to coordinate the work between the detection systems, this paper designs a transmission mode based on FPI bus-5g network communication, sends instructions to each detection module in real time and receives the data of each module, optimizes the pipeline production process according to the relevant data, and completes the pipeline detection work efficiently. When the detection equipment finds pipeline defects, the detection information will be fed back to the host computer, and then the host computer will process and classify the feedback of the detection data. It can receive the information from the detection module, realize the real-time monitoring and remote control of the detection; when a section of work section detection is completed, the upper computer module can make statistical analysis on the received data, so as to optimize and improve the pipeline production process. The flow chart of real-time communication transmission is shown in Figure 2.

3.1 Communication module

The main functions of communication module are data transmission and command transmission. It can ensure the timely collection of detection information, and realize the remote monitoring of the machine.

3.1.1 Data transmission

In the working process, the magnetic levitation pipeline detection system can send back the detection
value, defect type and location information in time, and display the machine power and other health status information in real time, which is convenient for the upper computer platform for further data processing. The upper computer platform feeds back the road information to the machine through the communication module, so that the machine can operate normally according to the specified route.

3.1.2 Instruction transmission
Under special circumstances, the upper computer platform will send corresponding instructions to the machine, such as abnormal production or detection found abnormal, timely feedback information. Prevent defects and hazards from escalating.

3.2 Upper computer module
The function of the upper computer module is to monitor the working state of the machine in real time, generate corresponding instructions in the emergency state, analyze the pipeline defect data, and control the positioning device to make action in time, mark, record and analyze the defect position.

According to the functional requirements of the upper computer module, the project team has developed the corresponding servo control real-time display software, which is convenient to intuitively understand the production status of the pipeline and the working status of the machine, and send the corresponding instructions when necessary to ensure the operation safety of the detection platform and the pipeline extruder.

Because there are many detection indexes in pipeline production, the project team has developed corresponding monitoring and control interfaces for the running state and detection functions of the machine, including the main monitoring interface, suspension attitude interface and data recording interface.

3.2.1 Main monitoring interface
The main monitoring interface includes control bar, external detection status bar, internal detection status bar, magnetic block suspension status bar and pipeline transportation status bar. The main monitoring interface can be accessed through the login interface, as shown in Figure 3 and Figure 4.

Figure 3 Login interface
Figure 4 Main interface

① Control bar
The control bar is mainly used to control the operation state of the detection system, including the "external camera switch" button, "external inspection push rod adjustment" button, "internal inspection camera switch" button, "Maglev Platform switch" button, "marker switch" button, "levitator lifting switch" button.

② External detection status bar
The external detection status bar mainly displays the real-time image and video stream captured by the external detection camera, and marks the detected defects, which is convenient for the staff to view the detection status. In addition, the measured outer diameter and roundness values of each length section on the outer surface of the pipeline and whether the pipeline has run out are output in the form of charts. The chart takes the measured pipe length as the horizontal axis, and marks the position where the size deviation and surface defects occur.

③ Internal inspection status bar
The internal inspection status bar transforms the point cloud data stream captured by the internal inspection camera into a three-dimensional point cloud model, and updates it in real time, providing visual graphics for the staff. In addition, the outer diameter and roundness values of each length segment of the detected inner surface of the pipeline are output in the form of chart.

④ Pipe section data column
The pipeline section data column mainly displays the thickness and eccentricity of the pipeline, and the pipeline thickness eccentricity detected by the platform is displayed in this data column in real time to ensure the production quality of the pipeline.

3.2.2 Suspension attitude interface
The suspension attitude interface shows the specific position and angle of the floater collected by the sensor in detail, which is convenient for the staff to view the working details of the floater and ensure the accuracy of the measurement. As shown in Figure 5
3.2.3 Data recording interface

The interface integrates the important production data detected by the system into the same interface, such as extrusion speed, production temperature, pipe inner diameter, pipe outer diameter, etc. At the same time, the system stores these data into the database to facilitate subsequent statistics and analysis to optimize the production process, as shown in Figure 6.

4. Result

4.1 A new display system of upper computer is designed.

According to the functional requirements of the upper machine module, the project team has developed the corresponding servo control real-time display software, which is easy to intuitively understand the production state of the pipeline and the working state of the machine, and send the corresponding instructions when necessary to ensure the safety of the testing platform and the pipeline extruder operation.

4.2 Real-time transmission system based on FPI bus.

This paper innovatively designs the detection method of carrying detection equipment on the platform of suspended magnetic block. In order to coordinate the work between detection systems, this paper designs a transmission mode based on FPI bus-5G network communication to send instructions to each detection module and receive data from each module in real time.
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