Intelligent Testing System of Performance Parameters of Flyer of Fly Frame

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Abstract: In order to test performance parameters of flyer of fly frame, a new testing system is developed. A differential mechanism of hybrid driving which imitates the variation of cylinder's diameter is introduced for the first time so as to test the changing law of press palm strength of flyer of fly frame at different rotate speed. It includes three parts: mechanics transmission, control and signal processing system. It can implement automatic control and data's collection and procession. The experimental results show that it meets the needs of technology and design, runs steadily, operates easily, and has accurate tests.

Keywords: performance parameters of flyer; hybrid driving; the mechanism of variours caliber; control method

1. Introduction

Fly frame is one of the important machines in the spinning. Flyer is the core parts of the fly frame. It is can be seen that the flyer's quality affects the fly frame's productivity and yarn quality directly. Therefore, the quality of flyer is very important. Whatever flyer's manufacturers, users even testing agencies can not be separated from related flyer performance testing equipments when determine the flyer's quality. In the flyers performance testing, the press yarn force of flyer presser is an important parameter, and it is also called press palm force. The variety of press yarn force has a direct impact on the quality of roving package, but the quality of roving package also has a direct impact on yarns' unwinding and levelness of textile process especially of high-count yarn levelness[1]. Therefore, testing the flyer is a necessary procedure before flyer installed on the fly frame. Now, it only can test the interval sizing of flyer's press palm force, that is only can test the flyer's press palm force when the yarns wind on the bobbins which diameter is constant, and it can not measure the flyer's press palm force when the bobbins' diameter is various. The flyer performance parameter tester that mentioned in references [2-4] only can test through the large, medium and small plates or manual adjust when change the bobbins' diameter, for this reason it can not reflect the press palm force under actual work condition and analyze the experimental data. In addition, the design structure of existing flyer performance test device is also unreasonable, and it need disassemble cantilever beam which connected with wires when change plates, so it is not only waste time and strength, inconvenient operation, but also exist safety problems, likely to cause failure.

In this paper, the test system adopts hybrid drive differential mechanism of variety caliber, sensor technology, dynamic stress and strain detect testing technology, PLC control frequency conversion [5-6] and computer graphics technology, and it can accomplish dynamic test of flyer's press palm force in the bobbin winding simulation process.

2. Working Principle

Driving mechanism of test system can be divided into two parts: one is the main motor drives spindles and support plates according to a pair of synchronous pulley, and this transmission line simulates flyer's regular working state. The other is the helper motor drives belt wheel, ratchet and pawl, center gear, planetary gear, a pair of planetary bevel gears, worm and gear, a pair of helical gear according to a pair of synchronous pulley. The sensor is installed on the one of helical gear. The two routes connected each other by the differential mechanism which constitutes by spindle, center gear, planetary gear and support plates. As shown in Fig.1.

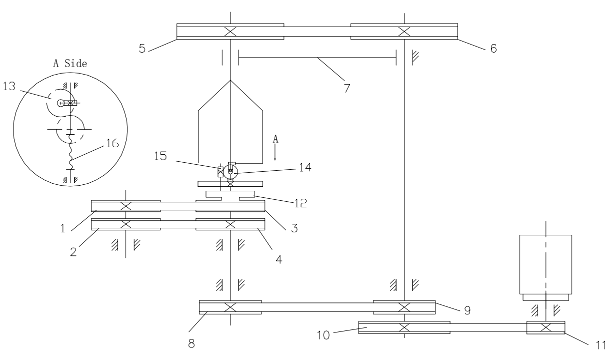

Figure 1. The scheme of transmission mechanism of testing system

In the Fig.1, 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11 are synchronous pulley, 7 is swing arm, 12 and 13 are gear, 14 is worm gear, 15 is worm, 16 is ballscrew.

In order to achieve one way transmission, the ratchet and passive pulley is fixed by the bolts, and the pawl fastened to the center gear by pawl shaft. Only when the helper motor rotates clockwise and the rotate speed is greater than the support plates, the planetary gear can rotate. On the contrary, the planetary gear dose not working and achieves one-way transmission. Turn the face cam, the two planetary gears only can separate, and achieve the sensor reset manual control. The rotation center of helical gear which installed sensor ought to coincide with the rotation center of press palm, so that the press palm is always touching with sensor in the testing process.

3. Mechanical functional requirements and design

The general functional requirements are simulate the roving bobbin's changing diameters under different speeds and then detect the flyer's press palm force dynamic and continuously, and have the characters of compact structure, accurate detection, reliable operation etc. The functional requirements of mechanical design are: the flyer's speed range is 200-1500r/min and the package diameters' changing range is ø45—260mm, in order to meet the design requirements of various winding technical. After the test, package diameter can be reset to the initial winding position for the next experiment. The initial and end points of sensor are corresponding to the bobbin diameter of ø45 and ø260.

Suppose the spindle rotate speed is n_0 , the center gear rotate speed is n_1, and the planetary bevel gear rotate speed is n_2. According to the relative motion principle, the relationship of the three rotate speeds can be written as following:

$$\frac{n_1 - n_0}{n_2} = -\frac{z_2}{z_1}$$

That is

$$n_2 = \frac{z_1}{z_2}(n_0 - n_1) \quad (1)$$

In the formula, z_1 is the number of tooth of center gear, z_2 is the number of tooth of planetary gear.

It is can be known from formula 1, as long as n_0 and n_1 unequal, then n_2 has output. The n_1 and helper motor are connected by the ratchet and pawl, only can drive one way, therefore, only when $n_1 > n_0$, the planetary bevel gear speed n_2 has output, the rotate turning of n_2 is just opposite with n_0 and n_1. On he contrary, the planetary bevel gear speed n_2 has no output.

The relationship of input and output of planetary gear shaft with sensor can be expressed by the following formula:

$$\theta_4 = i_1 \times i_2 \times \theta_3 \quad (2)$$

In the formula, θ_4 is the rotate angle of great helical gear in which the sensor place. θ_3 is the rotate angle of planetary bevel gear and worm shaft. i_1 is ratio of worm and gear. i_2 is ratio of helical gears.

For instance, the ratio of helical gear which installed sensor and bevel gear is 360:1. That is when the bevel gear rotates one circuit, the sensor rotate one degree. It equals to a layer of yarn around the bobbin. According to the actual measure roving diameter, determine angular displacement of sensor.

4. Control Segment

PLC programming control inverter is the chief control segment. It adopts PLC (Delta, DVP-20EX) and two inverters (Delta, VFD-B) to control two motors. That is, 1# inverter controls the helper motor and 2# inverter controls the main motor. The communication control between inverter and PLC is via RS-485 interface, and the two inverters are set by PLC program. The control mode of 2# inverter is controlled by external terminal, and 1# inverter is controlled by PLC program. According to bit operation of inverter can be realized the flyer's inching. As shown in Fig.2.

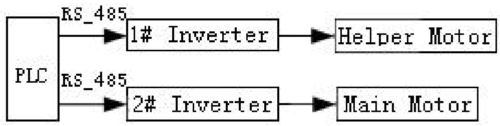

Figure 2. Control system diagram

This test system of PLC program designs as followings: Firstly, it should achieve the control requirements, so defined X_0, X_1, X_2, X_3, X_4, X_5, Y_0 and Y_1 as counter switch, launch, stop, testing, delivery, reset, main motor and helper motor respectively. Chart of PLC terminal connection is shown in Fig.3.

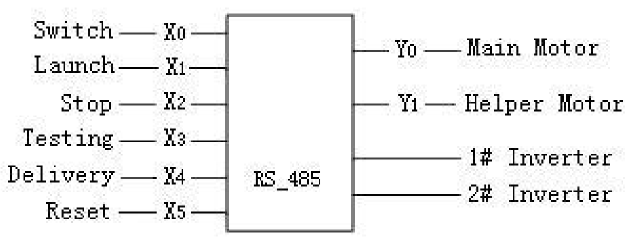

Figure 3. Chart of PLC terminal connection

Install a Hall sensor near planetary bevel gear, when the planetary bevel gear rotates one circle, then the Hall sensor sends a pulse signal, and the PLC count one time. After attain to the pre-given time, the PLC shuts down the

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signals that output to the inverter. Differential drive is mainly use two motors to achieve two degrees freedom input of differential gear train. It can achieve the given law by use of frequency control technology of asynchronous motor and PLC control technology. It is a kind of hybrid differential mechanism of stepless speed regulation.

According to the control requirements of flyer's press palm force write the flow chart as shown in Fig.4.

5. Test System

5.1 The composite of test system

The functional requirement of this test system is delivery the dynamic press palm force that detected by sensor to test system distortionless, and expressed the press palm force information that detected by computer in the form of curve chart. Signal processing part includes powder, pressure sensor, transmitter, A/D, and test software etc. Numerical standardization of the press palm force adopts statical method, or exerts a known force P_0 on the press palm force of working point, then get the output voltage value V_0, and save it into computer. When the detected press palm force is P_x, then it can be calculated by the following formula:

$$P_x = P_0 / V_0 \times V_x = K_V \times V_x \tag{3}$$

In the formula, V_x is the output voltage value when the press palm force is P_x, K_V is the measure sensitivity of instruments.

5.2 Testing procedure

Install the flyer that to be measured on the dummy bar of this test device, then lean the flyer presser on the sensor. The sensor is connected with the large helical gear. At the start of test, due to the differential mechanism, the sensor rotates external around the rotation center. As the test time is increasing, the distance of the sensor and the rotation center is increasing until to the set size. This procedure simulates the diameter increasing process of roving bobbin. Owing to centrifugal force, the flyer presser presses on the sensor closely, and rotates external with the sensor. The sensor's voltage is changing with the press palm force. The signals are converted into visible stress and strain value or graphics by the transmitter, then it completes dynamic test of the flyer press palm force. After measurement, counter-rotate the handle manual can reset the sensor in case of other flyer test.

6. Experimental results and analysis

Speed should be selected at the beginning of run, and then input the fashion batch number, radius, and open width of the detected flyer. During experiment, the flyer selects the radius for the 30mm and open width for the 102mm.

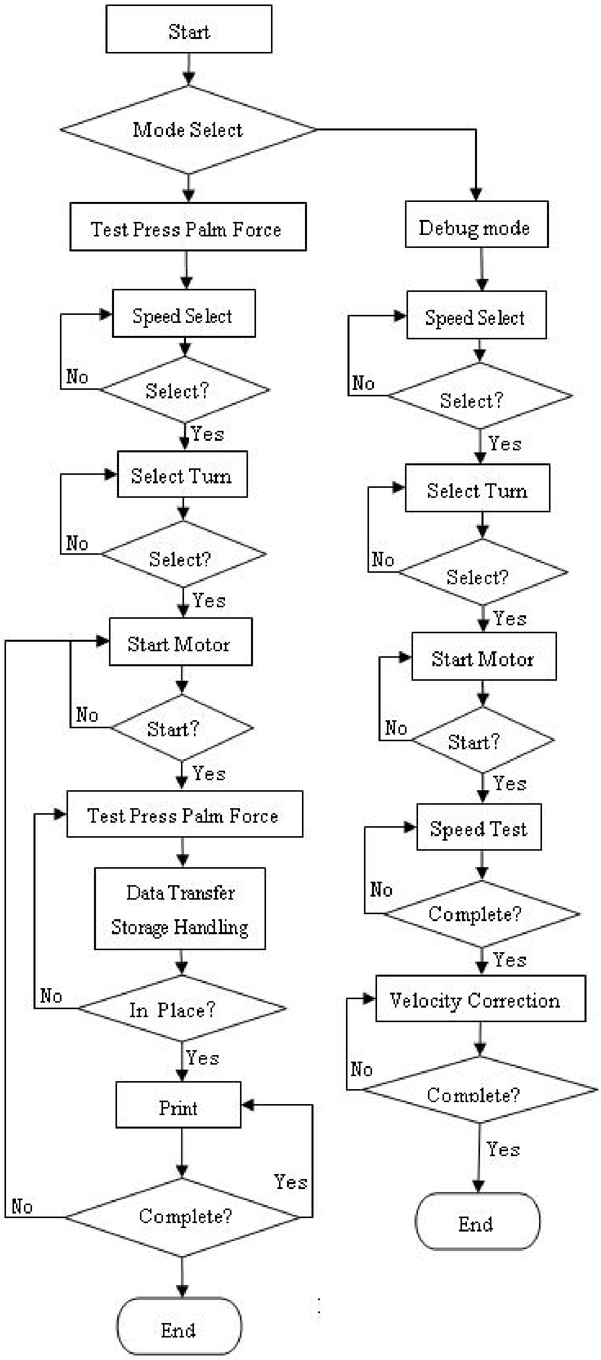

Figure 4. Flow chart of PLC control

According to the parameters that selected above, the experimental is conducted in the 800r/min. Through the experiment, measured the graph of press palm strength of flyer as shown in Fig.5. Therefore, we can see from Fig.5, the detect result are very accurate in the case of 800r/min.

After many tests in the laboratory, measure the flyer speed at the low speed 800r/min, the wireless transmitter can be send the data to what it want accurately. But the emitter stop working when the speed exceeds 800r/min, so it can not get data. Due to such situation, in order to obtain the data the flyer under high-speed rotation, so the experimental process makes a lot of modifications. As the system belongs to open loop control, which can be run without data transmission, and only complete parts of data measurement. Drive the emitter sends data to the receiver when stop. The system completes work during the trial operation as follows: sensor data acquisition, transmitter data conversion, the emitter converts the data through the A/D interface and stores in a specific register. When the system stop working, it completes work as following: emitter sends data, receiver receives data and send data to the PLC, PLC processes the data and store, then displayed through the touch-screen.

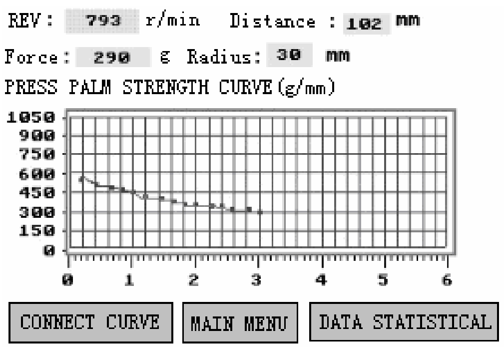

Figure 5. Curve graph of the press palm strength at the flyer speed of 800r/min

According to the experimental process that modified above, wireless transmission system detects the press palm force in the 1500r/min as shown in Fig.6.

The results show that wireless transmission system is also very accurate in the high speed when sends data according to above improvement.

7. Conclusions

(1) The actual operation results show that the test device achieves to simulate the bobbin's diameter changing, and prove that the dynamic test of flyer press palm force is effectively. It can meet pre-design requirements.

(2) Compared with the existing technology, the main advantage of this roving flyer press palm force test system is able to detect the continuous changes state of pressure that palm exerts on the bobbin in the course of bobbin rotation, then achieve to test the whole process intelligentized.

(3) The test system which based on PLC programming control and frequency convert control, it can meet the given speed law in the case of only alter the program without changing mechanical, running stable and easy to operate.

(4) The automation degree and measure precision of this test system is higher than former, and offers help to flyer performance parameters test and the flyer design, has a wide range of applications.

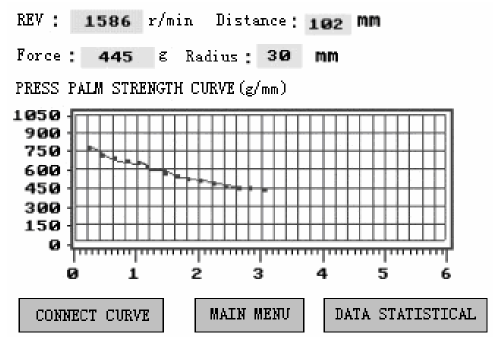

Figure 6. Curve graph of the press palm strength at the flyer speed of 1600r/min

8. Acknowledgment

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