

Large - scale Rectangular Ruler Automated Verification Device

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Abstract. This paper introduces a large-scale rectangular ruler automated verification device, which consists of photoelectric autocollimator and self-designed mechanical drive car and data automatic acquisition system. The design of mechanical structure part of the device refer to optical axis design, drive part, fixture device and wheel design. The design of control system of the device refer to hardware design and software design, and the hardware mainly uses singlechip system, and the software design is the process of the photoelectric autocollimator and the automatic data acquisition process. This devices can automated achieve vertical measurement data. The reliability of the device is verified by experimental comparison. The conclusion meets the requirement of the right angle test procedure.

1. Introduction

Rectangle ruler vertical detection method consists of optical gap method, amount of block comparison method and rectangular ruler to play the table method. The most commonly used method is optical gap method. The principle of it is to observe the actual gap through the visible gap to determine the size of the gap, the test results usually impacted by different visual testing personnel. Ruler measuring range in China is generally less than 600mm at present, and only little individual manufacturers can customize 1000mm. The detection object is generally 0 or 0 below of the rectangular ruler.

This device is designed to detect the vertical degree of large rectangular ruler, complete mechanical and electrical integration equipment, and establish an extended measurement system to form a complete product. The function of the verification device is as follows:

- (1) to complete the automatic acquisition, motion control and wireless transceiver function;
- (2) to achieve accurate position judgments and different span size adjustment function;
- (3) to achieve automatically save the function during the measurement process.

2. The structure of the device design

Since the size of the large-sized rectangular ruler is large, the volume of the autoradiograph must be small enough to measure in the course. Therefore, horizontal measurement is chosen in the detection process. The rectangular ruler is flattened. The width of the two sides of the ruler is different, so the shorter side is held with a thimble. It should ensure that the rectangular ruler is stable with no shaking.

2.1. Optical axis design

The design of measurement axis uses high-precision optical axis. The optical axis is used to fit to the measured ruler. It will be fixed through the base in the body. The optical axis has no race movement,



but axial movement, to ensure that the measurement axis and the side is line contact during the acquisition process. This design can ensure that the optical axis in the detection has not unnecessary radial round beating.

2.2. Drive part of the design

The transmission part is mainly driven by the stepping motor, the stepping motor is connected with a bevel gear, the other bevel gear is connected with the axle and the double bevel gear is in the engaged state, and the axle ends are respectively connected with the two driving wheels to form the transmission part.

The measurement part is mainly composed of measuring shaft. The measuring shaft and the drive wheel and auxiliary wheel are located on the same side. Since the measurement axis needs to be closely aligned with the side, and the verification device needs to move forward, the measurement of shaft thickness in the design process must be higher than the thickness of the four wheels, so as to ensure that the process of walking does not affect the measurement axis to collect data.

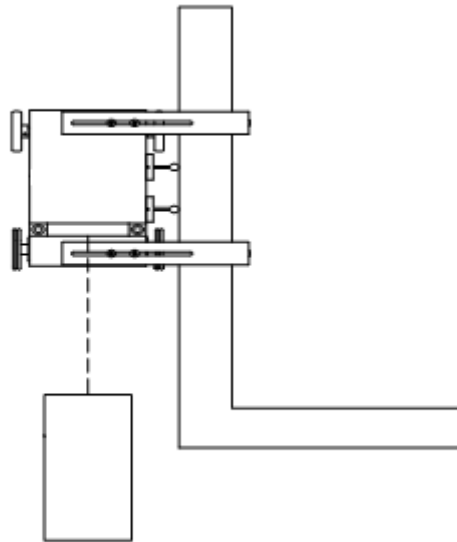


Figure 1. System connection diagram

2.3. Fixture device

The fixture part is an important device to determine whether the measured data is true or not. The setting of the clamping force needs to take into account the frictional force generated by the clamping block and the rectangular ruler.

If the friction is too large, the motor torque is not enough large to drive the entire structure forward. On the other hand, if the clamping force is too small, the measured plane will not be able to fit closely with the measuring shaft. This may lead to the wheel move left and right in the process and in separation with the ruler measured. The U-shaped connecting strip is fixed on the vehicle body, and the U-shaped groove is easy to move forward and backward. In order to facilitate the measurement of different types of rectangular rulers, the clamping device makes the measuring shaft of the automatic acquisition instrument always fit to the side of the rectangular ruler. The other of the U-shaped connecting strip is connected with a clamping block. The clamping block is connected by a spring washer to the U-shaped connecting strip. According to the different width of the rectangular rulers, U-shaped plate connects to the spring and the spring makes the rectangular rulers fit to the measurement axis through clamping block to gets the measurement data stable and reliable.

2.4. Wheel design

The left and right swing of the automatic acquisition device must be existed in the process. Therefore, the conventional wheel will lead to the distortion of the motion trajectory and increase the absolute clearance between the measuring axis and the measured surface.

The design uses the embedded wheel instead of the drive wheel, and the arc wheel instead of the auxiliary wheel, in order to meet the regulatory role, and appropriate to increase the friction of the wheel and the plane to ensure its stable movement.

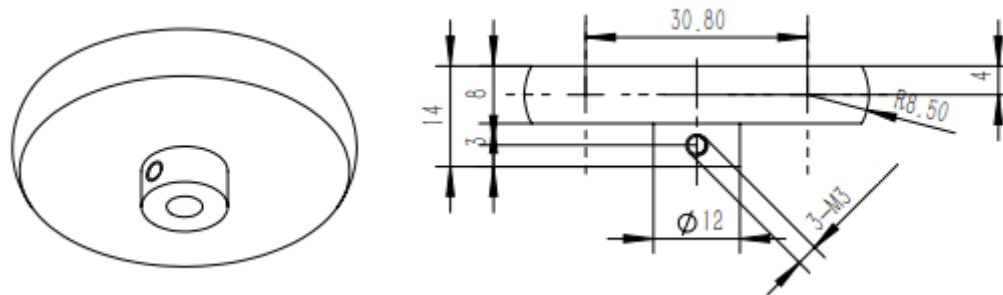


Figure 2. Radius wheel structure diagram

3. The control system design

According to the measurement principle and the overall program, the work flow in the concrete practical work is as shown in Figure 3.

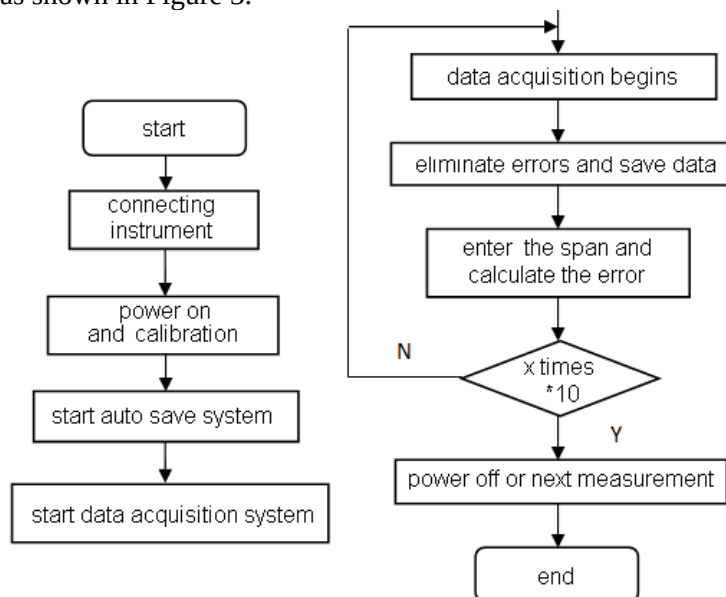


Figure 3. Total work flow chart

As shown in Figure 3, the center of the system is the process of the photoelectric autocollimator and the automatic data acquisition process. The number of data collected should be delineated according to the length of the measured gage.

Since the photoelectric self-collimator is set on the measured side of the ground through a dedicated tripod rack, the general measurement needs to be measured in a small vibration range of the room in the measurement process in order to avoid noisy environment and large vibration of the floor. Taking into account the impact of thermal deformation, the environment condition should be adjust to constant temperature and humidity state to avoid interference from other factors. In general, each measurement needs to be done ten times before the results be calculated.

As shown in Figure 4, the main hardware modules of the measurement system and the working relationship are shown. The core part of the system is STC89C52 microcontroller. It completes data collection, automatic data storage, traffic control, and the automatic acquisition instrument control.

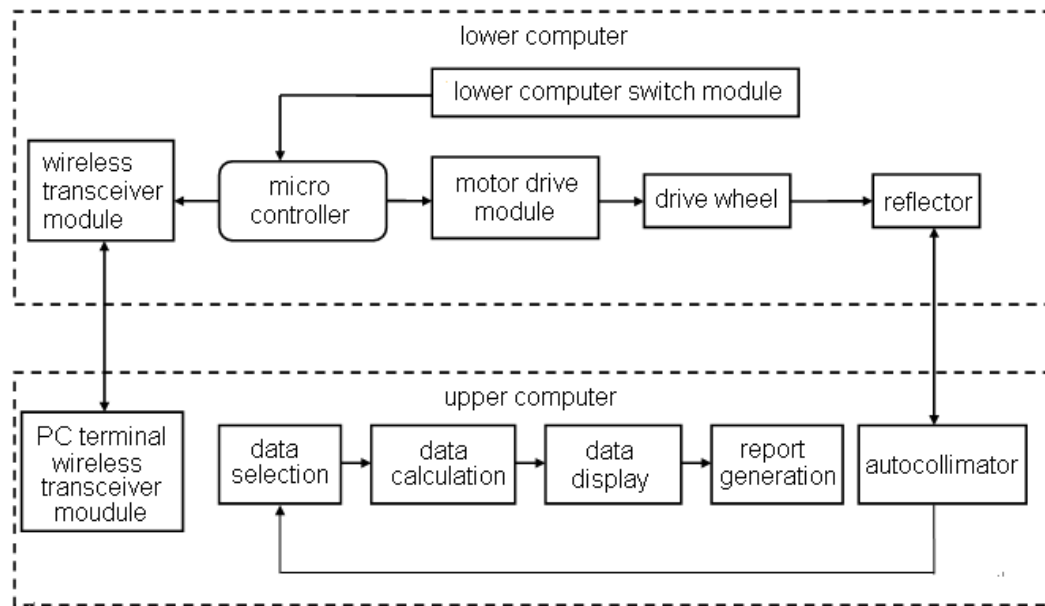


Figure 4. Hardware module and its working relationship diagram

4. Experimental results

The working environment during the inspection process is: constant temperature 19.96 °; humidity 41.6 °.

In the course of the experiment, 10 repeat experiments were carried out for the same rectangular scale, and the verticality was analyzed for each group of data. Then, the composite test was carried out. The following is a group of 10 data, as shown in Table 1.

Table 1. Rectangular ruler experimental data

Group \ No.										
	1	2	3	4	5	6	7	8	9	10
1	20.72	20.86	20.96	19.91	20.09	21.03	20.06	19.86	20.41	21.29
2	-35.23	-37.33	-39.01	-34.98	-35.77	-36.69	-35.02	-34.21	-35.63	-36.55
3	2.79	3.09	2.45	2.11	2.80	2.54	3.12	1.99	3.32	2.98
4	8.04	7.89	8.27	9.05	7.94	8.86	8.97	8.04	7.68	9.37
5	-3.85	-3.90	-2.92	-4.12	-4.67	-3.54	-3.05	-4.85	-4.19	-2.85
6	-37.54	-35.67	-35.74	-37.89	-36.48	-37.96	-35.25	-36.77	-34.99	-37.83
7	1.09	0.77	0.24	1.13	-0.03	2.01	1.73	1.60	0.89	1.84
8	57.43	57.88	56.13	58.49	56.62	57.71	58.05	56.36	57.57	56.24
9	26.69	25.17	26.98	27.22	26.74	25.72	28.02	25.85	26.46	27.63
10	3.71	4.43	3.29	3.11	4.83	5.07	4.86	3.99	4.58	3.81
11	73.08	73.77	74.21	72.63	73.81	74.26	72.87	73.33	72.90	74.59

12	-0.75	-0.92	-2.63	-1.86	-0.99	-2.07	-1.71	-1.42	-2.22	-1.45
13	-7.90	-8.59	-8.26	-9.03	-7.72	-8.68	-8.11	-7.35	-9.14	-7.99
14	67.90	65.90	65.78	66.25	67.16	65.93	67.47	66.64	65.95	67.16
15	21.90	23.95	22.89	23.23	21.39	24.05	23.56	22.72	23.41	22.37
16	7.90	7.11	6.95	6.79	8.13	7.74	7.48	8.25	7.56	6.90
17	-11.92	-13.00	-12.83	-12.54	-11.11	-10.98	-11.58	-10.18	-12.32	-13.12
18	-54.39	-54.99	-53.26	-52.75	-55.06	-53.94	-52.97	-54.01	-53.94	-52.99
Verticality	21.16	22.27	21.74	21.09	22.06	21.17	21.36	21.86	22.19	21.55

The ruler is $1000\text{mm} \times 630\text{mm}$, data is reached through the automated verification device. The collected values are relative values, and the results are analyzed using the minimum inclusive area method. The data analysis chart is shown in Figure 5.

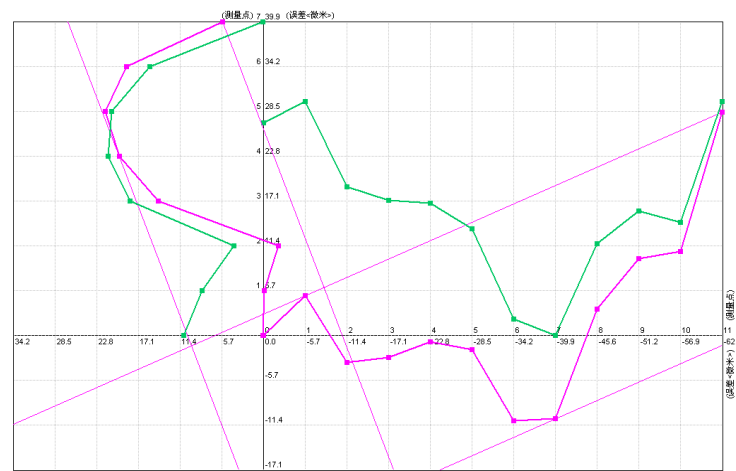


Figure 5. Error diagram with minimum area method of experimental data

In this paper, the experimental rectangular ruler is the calibration rectangular ruler, the calibration report shows the measured value is $23\mu\text{m}$ which is close to the experimental value. So this experiment has the reliability and the system is feasible.

5. Conclusion

In summary, the device described in this paper can greatly reduce the positioning error of large rectangular ruler measurement. It improves the measurement accuracy and meets the 《JJG7-2004 rectangular test procedures》 technical requirements. The optical path of the optoelectronic self-collimator can reach the longest distance up to 10m, so the device can detect the rectangular ruler side length up to 8m theoretically. With the increase in the length of the edge, the difficulty of straightening work of the optical path of will increase, so the use training of optical self-collimator is needed.

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