Design of Glass Flatness Semi-automatic Detection System

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Key Words: glass; flatness detection; displacement sensor; semi-automatic detection

Abstract: This article proposed a glass flatness detection system. The systems adopt 16 displacement sensors to detect multiple sample points on the glass surface simultaneously. Detection software controls pneumatic devices to realize glass feeding, clamping while displacement sensors' detection. Sensors output the detected displacement values in the form of the analog voltage to the data acquisition card. After the A/D cast, the values will be processed and get the thickness, width, flatness and the parallelism value of the glass. Through comparing with predefined limitation to justify whether the product fulfill the requirement. Test result show that proposed system could greatly improve the efficiency and precision of glasses flatness detection.

Introduction

There are some methods about flatness detection. Traditionally, they are usually divided into two categories of direct and indirect methods. The three-point method is frequently used to detect glass flatness. The assessment results of the three-point method were affected by the impact of the selected point, which caused non-unique results. And the results were also easy affected by the workers' operating experience, physical fatigue and other factors [1].

At present, domestic glass manufacturers usually use detection feet that is based on manual work to detect the flatness of the glass. Manual inspection will seriously reduce work efficiency.

To improve the test efficiency and precision, this paper proposed a glass flatness detection system, which using displacement sensors to detect the thickness of glass to judge whether the product meets the customers' requirements.

Detection System Design

Measurement Scheme and System Composition. This detect system adopt displacement sensors to obtain multiple glass surface sampling points' displacement. The least squares plane calculated by the least squares method will be the assessment datum plane. The whole testing process is controlled by using pneumatic devices and workers only need to place workpieces to the designated location and operate software to control pneumatic devices to get the flatness of glass. The detection system schematic diagram is shown in Fig. 1.

The system consists of a PC, a data acquisition (DAQ) card, 16 displacement sensors (10 on the surface, 6 on the side), cylinders and other auxiliary devices. The sensor's maximum displacement is 3mm, and the output voltage is 0-10V analog. The air compressor and the cylinder are used to control the clamping of the workpiece, the forward and backward movement of the worktable and the vertical movement of the sensor. The data acquisition card is Advantech PCI-1710U. This card can offer 16 single-ended/ 8 differential channels, 2 analog output channels, 16 digital I/O channels. Its resolution is 12 bits and its maximum sampling rate is 100 kS/s.

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In Fig. 1, sensors output the displacement values in the form of the analog voltage to the data acquisition card. After the A/D cast, the digital values will be processed by a PC program.

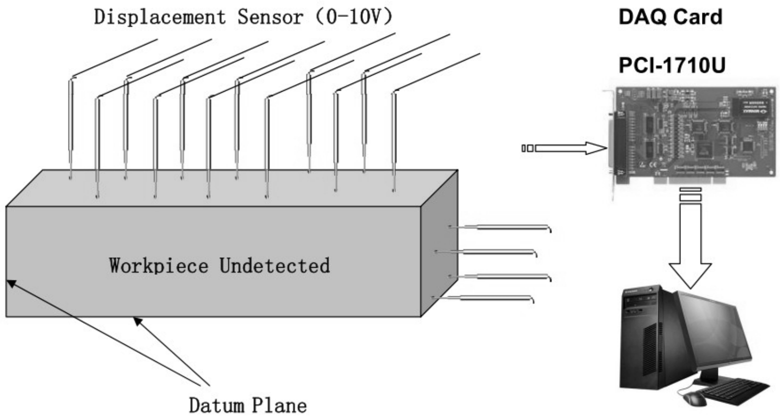


Fig. 1 The flatness detection diagram

Flatness Calculation. Although the related data acquired by measuring all sampling points can reflect the real situation of the measured plane, it is not the flatness error value. Due to the numerous sampling points of the system, we can use the least squares method that is commonly used abroad [3].The least square refers to a plane that has the minimum sum of the square of the distance between the respective sampling points and this plane. Take a point on the measured plane and its coordinate is $P_i(x_i, y_i, z_i)$. Set the ideal plane equation as $z = Ax + By + C$. In this case, according to the definition of the least square plane:

$$S_{min} = \sum_{i=1}^{n}(z_i - z)^2 = \sum_{i=1}^{n}(z_i - Ax - By - C)^2 \quad (1)$$

In order to let S have the minimum value, it must satisfy Eq. 2. Simplify Eq. 2 and get linear equations as Eq. 3.Use matrix method to solve the A, B and C, and eventually get a matrix only has data on the diagonal, so it greatly reduces the amount of computation and makes it relatively simple to solve.

$$\begin{cases} \frac{\partial S}{\partial A} = -2\sum_{i=1}^{n}(Z_i - Ax - By - C)x_i = 0 \\ \frac{\partial S}{\partial B} = -2\sum_{i=1}^{n}(Z_i - Ax - By - C)y_i = 0 \\ \frac{\partial S}{\partial C} = -2\sum_{i=1}^{n}(Z_i - Ax - By - C) = 0 \end{cases} \quad (2)$$

$$\begin{cases} (\sum x_i^2)A + (\sum x_i y_i)B + (\sum x_i)C = \sum x_i z_i \\ (\sum x_i y_i)A + (\sum y_i^2)B + (\sum y_i)C = \sum y_i z_i \\ (\sum x_i)A + (\sum y_i)B + nC = \sum z_i \end{cases} \quad (3)$$

Detection Software Design

Software Structure. As shown in Fig. 2, the main program consist of six modules: The control of the clamping part and the feed part of the cylinder; the calibration of the initial position of the displacement sensor; the control of the DAQ card to realize data collection; the built-in algorithm for data processing and the corresponding interface for data display; the storage of the result data and the realization of payback report generation; the management of historical data.

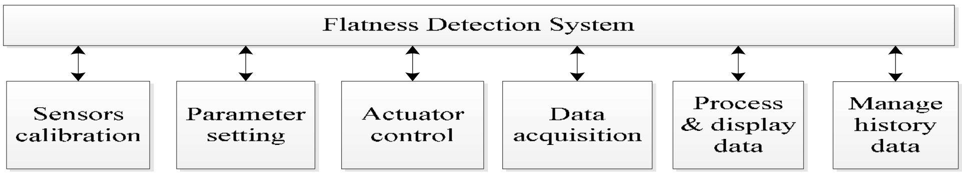
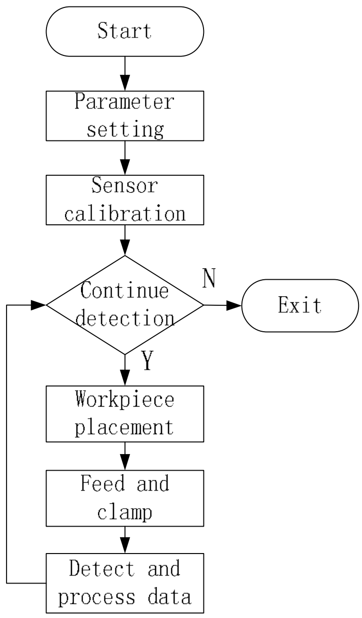


Fig. 2 Flatness detection software structure

Detection and Control Processes. The detection and control process based on the hardware structure and designed detection principle is shown in Fig. 3. After constructing the detection mechanism, first set the tolerance limitation and other parameters, then calibrate the sensors with a standard marble block and The measured values were record as zero point of each sensor. After these preparations, the glass could be place on the base plate, and feed the base plate together with glass and clamp the glass to a fixed location, and then start data collection and calculate to get related values and display the result.

Human-Computer Interface Design. Fig. 4 shows the main program interface of developed system. Fig. 5 is the calibration interface and Fig. 6 is the parameter setting interface.



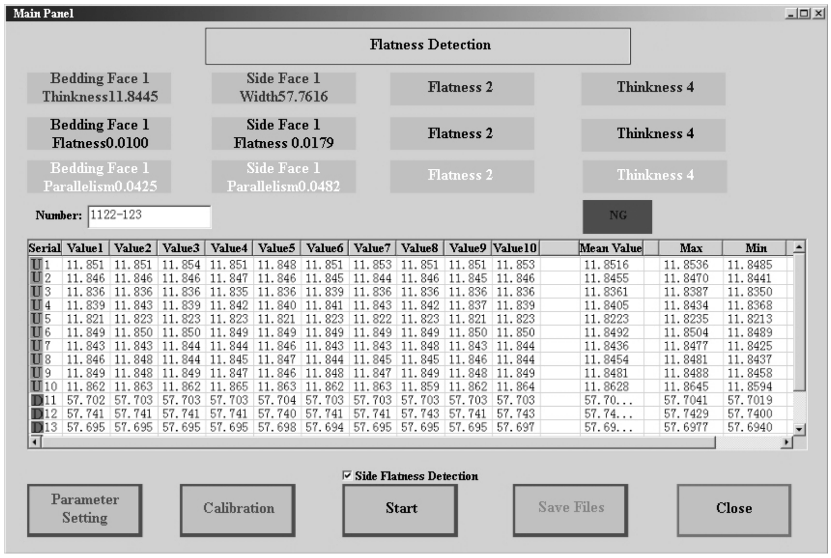
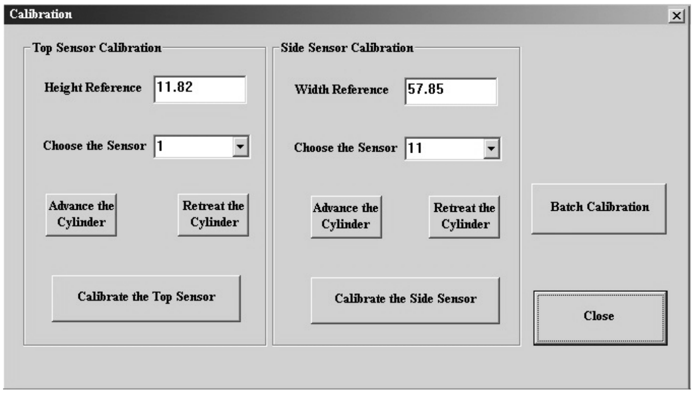


Fig. 3 Detection process diagram

Fig. 4 Main program interface

Testing and Conclusion

The detection software was developed with VC6.0. The glass flatness detection system was tested to verify the function. Sample ten sampling points on the upper surface of the glass ten times respectively as shown in Fig. 7. The figure show that ten times' sampled value of the same sensor is basically the same, the general flatness error value of the glass from this figure. Obviously, it's the distance between the highest line and the lowest line. In actual calculation, the maximum and minimum values of each detection point will be removed to reduce errors. Placing the same glass under our system and the coordinate measuring instrument respectively to detect, the detection results are almost the same and they are in the tolerance range. So the developed system has been proved to be feasible. This system has been put into use and it can detect a piece of glass in ten seconds, which greatly increases the detection efficiency and precision.



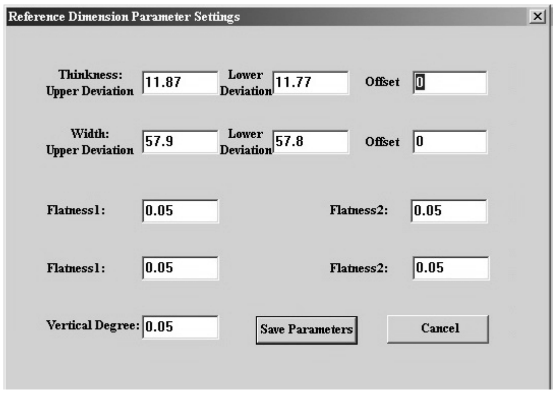


Fig. 5 Sensor calibration interface   Fig. 6. Parameter setting interface

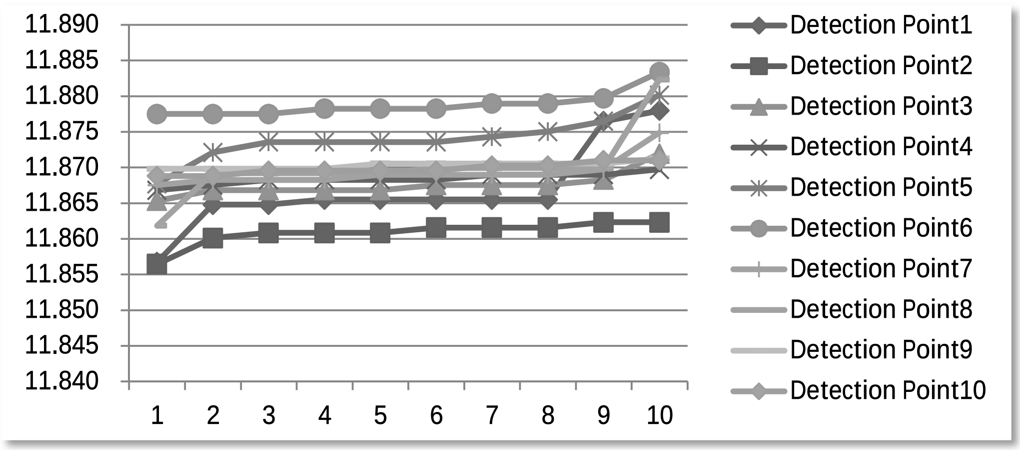


Fig. 7 Measured values of the 10 sensors on the bedding face of glass

Acknowledgements

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