Photoelectric Detection of Hole Shape and Size for Large Plate Parts

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Abstract. The measurement of hole shape and size of large plate parts has always been a technical problem. The article proposes a technology to use non-contact photoelectric detection technology for online detection of the shape and position of large plate-shaped workpieces. The detection principle is: the control system controls the photoelectric detection system to move in a straight line along the guide rail at a uniform speed, and the large plate-shaped workpiece the hole shape and size are measured, and the lighting system moves synchronously with the photoelectric detection system to provide the light source for it. The images collected by the photoelectric detection system are processed through digital image processing and image splicing technology to realize the hole shape and size of large plate workpieces. Non-contact measurement.

Keywords: Large Panel Parts, Non-Contact, Photoelectric Detection, Image Processing

1. Introduction
On-line inspection technology is a newly developed advanced inspection method, which combines measurement technology with production technology and automatic control principles. To achieve 100% inspection of the products on the production line, and to always be in the best condition during the production process [1-3]. It comprehensively uses sensing technology, computing technology and automatic control principles. It belongs to the category of information technology, including information collection, transmission and processing. On-line detection technology has outstanding advantages, which can ensure product quality, eliminate defective products as much as possible, and save consumption. The production process is always carried out under the condition of automatic control and automatic adjustment, which not only reduces the requirements on the technical level of the operators, but also reduces the number of downtimes and improves the production efficiency [4-6]. It does not rely on human operation. In addition, it also has the advantage of a high degree of production automation, which reduces the labor intensity of the staff and avoids human errors in the production process [7,8]. It can also work in a variety of harsh production conditions, such as production workshops and factory areas with harsh conditions, and can not accept various bad environmental influences, such as high temperature, poisonous gas, strong magnetic field, and dust. It
is precisely because of the powerful function and relatively obvious superiority of online detection technology that various developed industrial countries are racing to develop this technology and develop various online detection instruments [9, 10].

2. Overall Scheme Design
This scheme is to carry out online photoelectric detection for the distance between the hole distance of the standard component of large plate parts and the distance from the center of the center line to the right-angle side of the standard component of large plate parts, that is, the baseline. As shown in Figure 1.

![Figure 1. Standard samples of large plate parts](image1)

This program consists of a console, mechanical transmission device, photoelectric detection system, tested standard components and computer digital image processing system. During detection, the console sends instructions to control the mechanical transmission device, so that the CCD-loaded trolley makes a uniform linear motion on the guide rail, and the photoelectric detection system takes real-time shooting of the tested standard components, and sends the shooting images back to the computer. Use digital image processing technology to process the returned image to detect the hole distance and center line. The test results are displayed on the computer in real time.

![Figure 2. Schematic diagram of the detection system structure](image2)

1. Light source; 2. mechanical transmission system I; 3. fixed workbench I; 4. sheet standard components; 5. photoelectric detection system; 6. mechanical transmission system II; 7. fixed workbench II; 8. console; 9. computer digital image processing system

3. Mechanical Transmission System
The mechanical transmission part is shown in Figure 3. After receiving the transmission command, the servo motor drives the gear and the rack to cooperate with the gear at the speed of the coupling, so that the trolley equipped with the photoelectric detection image system is linearized along the guide rail at a constant speed. movement. If there are other needs for the detection speed, the speed of the servo motor can be adjusted through the encoder. The motor is equipped with an encoder with counting
function. The hole distance between the holes can be obtained by calculating the product of the motor speed and the gear circumference.

![Schematic diagram of mechanical transmission](image)

**Figure 3.** Schematic diagram of mechanical transmission

1 guide rail; 2 racks; 3 motors; 4 couplings; 5 gears; 6 carts

The mechanical transmission part is shown in Figure 3. After receiving the transmission command, the servo motor drives the gear to cooperate with the rack through the coupling at a speed of speed, so that the trolley equipped with the photoelectric detection imaging system will perform a straight line along the guide rail at a constant speed. If there are other needs for the detection speed, the speed of the servo motor can be adjusted through the encoder. The motor is equipped with an encoder with counting function. The hole distance between the holes can be obtained by calculating the product of the motor speed and the gear circumference.

4. Photoelectric Detection System

The photoelectric detection system is mounted on the trolley. It uses a series of ultra-high-speed digital image sensors and optical lenses to perform real-time shooting. The system is shown in Figure 4. It consists of a lens, a power supply, a controller host, a console, and a monitor composition.

![Composition diagram of photoelectric detection system](image)

**Figure 4.** Composition diagram of photoelectric detection system

The arm of the trolley is equipped with two receiving camera systems. The angles are perpendicular to the two detection surfaces of the standard iron tower member under test. The obtained images are transmitted to the computer in real time through the controller host for processing. The connection control system and the computer, through the setting of the computer program, the image processing is automatically carried out in the computer, without the operation and processing of the staff. The processed images and measurement results are then sent back to the controller host and displayed on the monitor in real time. It can also be directly displayed on the computer screen. Whether an additional monitor is required requires additional consideration. The controller host uses a separate power supply.
In order to reduce the error caused by the longitudinal defocus of the inspected part along the optical axis and eliminate the measurement error caused by the movement of the workpiece in the vertical optical axis direction. The front lens uses a telecentric optical path. As shown in Figure 5.

Figure 5. Schematic diagram of telecentric light path

The telecentric optical path is to set a diaphragm at the focal point of the object mirror image, and the image focal point of the objective lens coincides with the object focal point of the objective lens, so that the light parallel to the main optical axis will still be emitted parallel to the main optical axis after incident, thereby solving the workpiece The defocus aberrations caused by the different geometric elements of the device are not in the same plane. The workpiece to be tested is placed on a plane that is conjugated to the receiving surface and can be imaged on the photosensitive receiving surface according to a certain and accurate magnification requirement. When the measured workpiece is placed on a plane conjugated to the receiving surface, it can be solved by adjusting the position of the photoelectric detection system.

As shown in Figure 6, the optical lens is fixed on the rack and matched with it. The big gear drives the photoelectric detection system on the rack to move up and down. In order to keep 90 degrees with the detection surface of the tested workpiece, the rack can be positioned by a sleeve fixed on the trolley arm to ensure that the tested workpiece can be in a plane position conjugate to the receiving surface. The big gear and the small gear bite and are connected with the stepping motor through a coupling, and are fixed on the trolley arm of the transmission system through a connecting frame. The distance between the measured workpiece and the lens can be detected by a semiconductor laser rangefinder fixed on the rack, which is actively captured and monitored by the computer.

Figure 6. Schematic diagram of lens feed mechanism

1 trolley arm; 2 small gears; 3 couplings; 4 stepper motors; 5 large gears; 6 racks; 7CCDs; 8 optical lenses; 9 sleeves; 10 connecting frames; 11 semiconductor laser rangefinders

The lighting system is as shown in 6, there is a lead screw under the tested workpiece, which is connected to the entire mechanical transmission system for movement. Its function is to drive the trolley fixed on it to move, and the light source of illumination is placed on the trolley, which ensures the synchronous travel of the measured workpiece and the light source. The lighting uses a light source, which illuminates the DUT from behind and is directly received by the camera.
5. Image Processing System
The images taken by the camera system are transmitted to the computer system for image processing such as stitching and correction. Splicing mode selects the template matching mode.
Due to technical problems, the collected images will contain various noises, which will affect the quality of the collected images to a large extent. In order to make the captured images reach the required level of measurement in terms of clarity and contrast, image processing must be carried out at this time to make the image features obvious and improve to the extent required. The general method is to use image enhancement methods. The median filter and the corrosion expansion filter are combined to eliminate the noise in the image.

There is a grayscale difference between adjacent pixels in the Shanshao image. At this time, you can set the floating threshold in the way of assignment. When the grayscale difference of the pixel is less than or equal to the threshold, then one of the pixels is assigned as the grayscale of the pixel. When the difference is greater than the threshold, the pixel is assigned a value. Use operators for edge extraction. Take multiple pixels for the extracted edges, and then use mathematical algorithms to fit the edges of the workpiece.

For image processing of holes in large plate parts, the edges of the holes can be fitted first, and then the centroid fitting of the holes can be known. It can also be fitted to the baseline fitting of the standard components of large plate parts. Furthermore, the distance from the hole center to the right-angle side is calculated by the coordinate values of the hole center and the right-angle side obtained by fitting. As shown in Figure 7.

![Image Processing Flow Diagram](image_url)

**Figure 7. Schematic diagram of image processing flow**

6. Summary
(1) A system that uses non-contact photometric detection technology for online detection of the shape and position of large plate-type workpieces is proposed. The system is composed of a control system, a photometric detection system, a lighting system, and a computer digital image processing system;

(2) Analyze the detection principle of non-contact photometric detection technology, which is specifically: the photometric detection system is controlled by the control system to move in a uniform linear motion along the guide rail to measure the hole shape and size of the measured large plate workpiece. The lighting system follows the photometric detection. The synchronous motion of the system provides the light source for it, and the image collected by the photometric detection system is processed through digital image processing and image splicing technology, so as to realize the non-contact measurement of the hole shape and size of the large plate workpiece.

(3) Analyze the specific operation and work flow of each key technology in non-contact photometric detection technology, laying a solid foundation for subsequent similar scientific research projects.

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