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Intelligent Defect Detection Platform for High-Reflective Electrode Sheets

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Abstract: *To address the inefficiency of manual inspection for high-reflective electrode sheets (critical to battery performance), an intelligent defect detection platform is designed. It uses a clamping device to flip material boxes, a vacuum system to lift trays (enabling double-sided inspection), and a servo-driven system for full coverage. Experiments confirm the platform boosts detection efficiency and accuracy significantly.*
Keywords: *Electrode sheets, Defect detection, Intelligent inspection platform, Defect detection*

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I. Introduction

Detecting defects on high-reflective metal surfaces is a core challenge in industrial vision [1,2,3]. Traditional methods like lighting correction and filtering improve image quality but lack robustness for complex defects [4,5].

To address highlight interference, J.-S. Park and J.T. Tou [2] separated highlights from multi-angle monochrome images to calculate 3D specular surface normals, breaking through metal surface highlight processing limitations. Sun [7] pre-trained networks on ImageNet and proposed Adaptive Multi-scale Image Collection (AMIC) for transfer learning, enhancing detection performance effectively.

Traditional methods are limited in complex scenarios, while deep learning is prone to overexposure and diffuse reflection interference [6,7]. This study combines specialized imaging and deep learning to boost data quality and feature extraction, achieving efficient automated detection for high-reflective metal products.

II. Design of the Intelligent Detection System for High-Reflective Electrode Sheets

During the production of electrode sheets, common defects include deformation, indentation, dirt, and scratches. As shown in Figure 1, electrode sheets may experience surface dents or bulges (deformation) due to external forces or improper processing, small indentations caused by excessive pressure (indentation), contamination (dirt), and surface scratches (scratches).

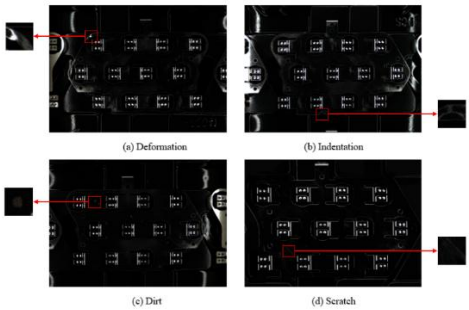

Fig 1 Typical Defect Examples of 4×4 Tray Pieces

2.1 Mechanical and Software Systems of the Detection System

The system consists of hardware and software components. The hardware includes industrial cameras, lenses, light sources, computers, sensors, cylinders, and air source processing units, responsible for material presentation, image acquisition, and action execution. The software includes PLC control logic, vision algorithms, data storage, and the UI interface, responsible for action sequencing, image processing, and status monitoring.

The mechanical movement of the system primarily consists of the clamping mechanism, flipping mechanism, and transportation system, with the following specific functions:

1. Clamping Mechanism: This mechanism uses a cylinder to control the clamping of the electrode sheet from the tray and accurately move it to the inspection position. The extension and retraction of the cylinder ensure stability and precision during the clamping process.
2. Flipping Mechanism: The flipping mechanism is driven by a cylinder, enabling the electrode sheet to be flipped 180 degrees. This action displays both the front and back sides of the electrode sheet to the vision system, ensuring that the entire surface is captured during image acquisition.
3. Transportation System: The transportation system ensures the stable movement of the electrode sheet during the inspection process, preventing deviations caused by unstable motion. After completing the inspection, the electrode sheet returns to its original position in preparation for the next operation.

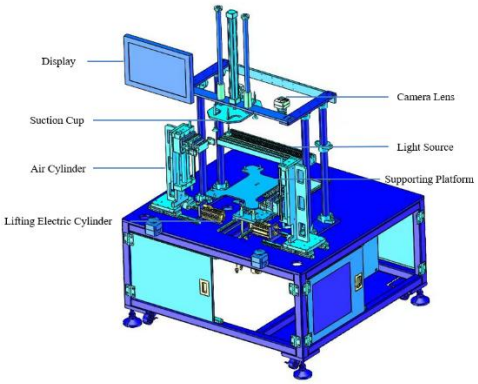

Fig 2 Schematic Diagram of the Mechanical Structure of the Intelligent Detection System for High-Reflective Electrode Sheets

2.2 System Workflow

After the system starts, the suction cup begins working to lift the material tray. The PLC-controlled motor moves the object to the inspection position, after which the line scan coaxial light source is activated and the inspection platform returns to capture the image. The image is then sent to the detection module for defect recognition. Once the object returns to its original position, the clamping cylinder starts working, lifting and inverting the object. The process is then repeated to complete the full inspection of the object.

III. Experimental Results

Experimental data were collected from the actual production scenario of 4×4 specification trays in a manufacturing plant. A total of 800 valid sample images were acquired using the Hikvision MV-CL042-91GC line scan camera equipped with the MVL-AF5028M-M42A industrial lens. A total of 12,000 pieces were verified, with a defect detection rate of 96.5%, which meets the production requirements. The detection results are shown below.

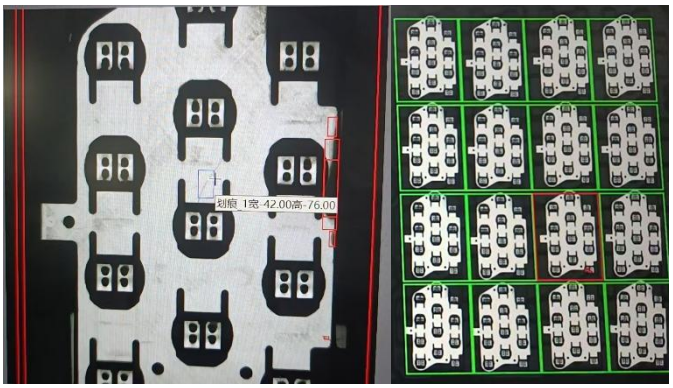

Fig 3 Schematic of Batch Detection Results for 4×4 Tray Pieces

IV. Conclusion

This study developed an intelligent defect detection platform for high-reflective electrode sheets. Featuring automated processes, open hardware architecture, optimized vision technology and an improved deep learning model, it boosts detection efficiency/accuracy with easy operation. Compared to manual inspection, the

platform cuts detection time by 1/3, reducing labor costs while ensuring continuous production. Highly versatile, it can be extended to other high-reflective material fields, creating substantial economic benefits.

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