Execution process monitoring technology for electronic assembly production

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Abstract. With the increasing demand for the patterning and refinement of electronic components, the structural design of electronic products is complicated, which in turn increases the complexity of electronic assembly production. Therefore, the traditional production execution monitoring information cannot meet the current requirements for assembly execution monitoring. This paper proposes process monitoring technology for electronic assembly production, including the execution process quality monitoring technology for electronic assembly production and the visual monitoring technology based on electronic assembly production instant Kanban. The two technologies achieve the refined management of electronic assembly production and the control of the execution process.

1. Introduction

The electronic assembly production process is the entire process of blank PCB board after SMT mount and then through the DIP plug-in. The full assembly process of the electronic assembly line includes Automatic Plugin Technology, Surface Mount Technology, Lead Free Wave Peak Welding Wire Technology, Selective Peak Welding Technology, Assembly and Assembly Technology.

The electronic assembly line is a highly automated production line, in which some processes have been fully automated. Therefore, the traditional production execution monitoring information can no longer meet the requirements and there is a need for more intuitive and effective electronic assembly to implement the production process monitoring means. The execution process monitoring technology for electronic assembly production proposed in this paper can effectively utilize the product quality information, production process schedule, equipment and other data. In addition, the production situation is displayed in real time through Kanban technology, which realizes the monitoring of the whole process and all aspects of electronic assembly production execution.

At home and abroad, there have been many studies on the practical application of electronic assembly production process monitoring technology. In the electronic assembly line, the management of product quality and the traceability of quality problems are important factors in the efficiency of the entire production line. The application of MES technology to solve complex quality management problems in electronic assembly lines has attracted wide attention of researchers. Zhang Yi et al studied the application of MES system based on dynamic quality control in PCB board assembly industry and proposed the quality control technology and method for electronic assembly production line [1]. Han
Fang has done research on the quality control of PCB production process in small batches and varieties, and made a key analysis on the factors affecting quality and data control methods in PCB production process [2]. Aiming at the problem of the influence of noise information on the quality of measurement data in quality monitoring and adjustment, Wang Pei et al. proposed a quality control and adjustment method for manufacturing process based on the integration of statistical process control and engineering process control [3]. Toyota Motor Corporation originally created Kanban in the 1950s from the operating mechanism of the supermarket. It was created as a delivery tool for production and delivery instructions and played an important role in the management of production operations at that time. Xiao Yan studied the modelling and simulation technology of the Kanban system in the lean production mode for the traditional production efficiency of the engine shop bus [4]. Yang Guohua studied the Kanban technology of complex assembly line and the material circulation distribution method of production line based on Kanban, and carried out empirical research to verify the feasibility [5].

Although there have been some researches on the practical application of production execution process monitoring technology at home and abroad, it has not been involved in the execution process monitoring technology for electronic assembly production. This paper focuses on the problem of electronic assembly production execution monitoring, combined with MES development. Finally, it focuses on the research of execution process monitoring technology for electronic assembly production to realize the refined control of the electronic assembly production.

2. The framework of the execution process monitoring technology for electronic assembly production

The electronic assembly production system monitors and manages the entire process of order production tasks. The electronic assembly production process is as follows: ERP obtains production order planning, electronic assembly production task management, mounting, plug-in, reflow soldering, inspection and rework, and completion delivery. The framework of the execution process monitoring technology for electronic assembly production is shown in Figure 1.

![Figure 1. The framework of the technology.](image-url)
quality problems will seriously affect the execution efficiency of product production and reduce the product supply capacity of the production line. On the other hand, the quality control cost of the product is high and the yield is limited. Therefore, based on the process monitoring for electronic assembly production, the quality control technology for the execution process of electronic assembly production is further studied and derived. Execution process quality monitoring not only ensures effective quality control in the electronic assembly production process, but also improves yield and reduces production costs, which enables automation and efficiency of electronic assembly production.

(2) The visual monitoring technology based on electronic assembly production instant Kanban. Through the product Kanban, order Kanban, and equipment Kanban during the electronic assembly process, the system displays and monitors the production status of each assembly in real time. The dispatcher makes timely strategy and production adjustments based on the real-time production data provided by the instant Kanban, which in turn improves the monitoring capability of the production process and the efficiency of electronic assembly production.

3. Key technology

There are two characteristics in the process of electronic assembly production execution monitoring:

(1) Many monitoring projects and high quality monitoring requirements. (2) Real-time data generation is fast and monitoring data is complex. The execution process quality monitoring technology for electronic assembly production can effectively realize the quality monitoring in the production process of each project and ensure the quality monitoring of the electronic assembly throughout the whole process, which realizes the quality control of the electronic assembly production control and information statistics. Based on the real-time data in the production process, the electronic assembly production instant Kanban technology displays the product status in real time, achieving more intuitive and effective monitoring.

3.1. Quality monitoring technology for electronic assembly production process

3.1.1 Quality monitoring process for electronic assembly production. Based on the analysis of the business process oriented to electronic assembly production, with the main goal of refined execution management and control, this paper summarizes the quality monitoring process of electronic assembly production execution process. Figure 2 shows the quality monitoring process in production processing:

![Figure 2. Quality monitoring process in production.](image-url)
of the data. The quality monitoring technology for electronic assembly production process is carried out according to the following five steps:

- **Quality inspection after solder paste printing.** After the solder paste is printed, the solder paste inspection machine monitors the height, area, and volume of the solder paste and then transmits real-time quality inspection data to the decision and control layer.
- **AOI detection after mounting.** After the SMT mounting is completed, the Automatic Optical Inspection monitors whether the assembly has quality problems such as lack of material, wrong materials, and defects in the device itself.
- **ICT detection after plug-in.** After the plugin is completed, In-Circuit-Tester monitors whether the assembly has problems such as open circuit, short circuit, and incomplete part soldering.
- **AOI testing after welding.** After the reflow soldering is completed, the Automatic Optical Inspection again monitors the assembly for solder joint defects, lack of material, etc. Moreover, it transmits the location information of the solder joint defects and missing material to the decision-making layer.
- **Electrical performance testing.** After the electronic assembly is completed, various electronic test instruments and equipment detect various electrical performance indicators of the assembly. After the electronic assembly reach the electrical performance indicators, the decision-making and control layer will store the process quality data and report the completion of the delivery to the system to realize the digital closed-loop process of the electronic assembly plan and production execution.

### 3.1.2 Association of complex quality data in the execution of electronic assembly production

In order to solve the problem that the quality information dispersion, organizational disorder, and low utilization rate in electronic assembly production seriously affect the production efficiency of electronic assembly and improve the statistical and analyzability of quality information, this paper proposes association of complex quality data in the execution of electronic assembly production. This technology solves the problem of disordered quality and weak correlation of the quality data of the electronic assembly line and successfully realizes the quality monitoring of the electronic assembly production process.

The relationship analysis of complex quality data is shown in Figure 3.

![Figure 3. Association mechanism for complex quality data.](image-url)

The electronic assembly production line management system and equipment data are related by the production order number and material code to realize the association between the order and the material.
defect device and the material information to the material defect, and complete the data connection from the user demand to the quality data. Through the association of complex quality data in the execution of electronic assembly production, the technology improves the correlation of complex quality data and enables effective monitoring of the quality of electronic assembly processes.

3.2. **Visual monitoring technology based on electronic assembly production instant Kanban.**

Kanban technology is an effective means of achieving just-in-time production. Production of instant Kanban is an important function of electronic assembly production process monitoring. In addition, it plays an important role in improving production efficiency. Aiming at the highly automated process flow in the electronic assembly production line, combined with the Kanban concept and the workshop visualization management, the real-time databased electronic assembly production Kanban technical solution is proposed. The framework of visual monitoring technology based on electronic assembly production instant Kanban, as shown in Figure 4 below:

The data acquisition of electronic assembly production instant Kanban mainly comes from two aspects: one is the order task related data, such as the electronic assembly production material-supporting situation; the second is the real-time data of the equipment during the execution process. SMT mounter, Automatic Plug-in machine, Manual Plug-in machine, Solder Paste Detector, Automatic Optical Inspection, Marking machine and other equipment in electronic assembly production have their own database for storing their own production execution data and related Information, which is the source of data for instant assembly of electronic assembly production. The system acquires data and implements data association according to each data association condition, and then uses statistical methods to classify data. The final real-time data is classified into three categories: production execution data, production prompt data, and real-time analysis data.

According to the above-mentioned electronic assembly production instant Kanban technology, combined with the actual situation of electronic assembly production, the system application of the electronic assembly production Kanban is designed, as shown in Figure 5 below:
According to actual needs, the electronic assembly production instant Kanban will provide the following information:

- Production schedule: the shop manager and the enterprise manager monitor each assembly task through the order Kanban, and can monitor the execution status of the entire assembly task to realize real-time monitoring of the entire process of the order.

- Equipment status and assembly status information: the staff can monitor the real-time execution status of each assembly in any equipment and the quality status of the assembly through the equipment Kanban and product Kanban, which enables status monitoring of the equipment and assembly execution process.

- Real-time analysis of the quality of the assembly: the staff can view the quality data during production execution according to SPC statistical results and implement effective control of product quality during execution.

4. Experimental verification

This paper studies the execution process monitoring technology for electronic assembly production. Based on the two key technologies discussed above, using Win Form, ASP.NET and other technologies under the .NET platform, we have developed the manufacturing execution management system for electronic assembly production. Manufacturing execution system realizes the application of these two application technologies in actual production.
Entering the order execution-monitoring Kanban, you can see the execution of the electronic assembly with the order as the main part. You can see the execution status of each process module, such as production preparation, printing, mounting, reflow oven welding, automatic optical inspection and testing. The execution of each process is visually identified by text and associated colours.

Equipment execution-monitoring Kanban mainly includes two aspects for the display of equipment execution data. The first is the real-time data of the current equipment operation, including the quantity information of the mounting materials, the information of the feed quantity, the information of the throwing, etc. This is the instant window for the production line administrator to monitor the running status of the equipment. The second is that the real-time monitoring Kanban of the equipment mainly displays the current equipment. For the remaining and use of each material, when the remaining material is lower than the set alarm value, the material alarm prompts.
First, each test record of the AOI is displayed and the new test records are marked in green. Click on each inspection record to view the list of defects in the inspection, including the basic defect number, defect type, defective part number, etc. In addition to the list of defects, clicking on a single defect record can display the relevant image of the current defect. In the above figure, the three images are the defect image, the template thumbnail and the template image. At the same time, in the template, it can automatically mark according to the coordinate position of the defect position, which greatly facilitates the user's view of the defect record.

Based on the sample data, Statistical Process Control technology controls key process characteristics. Similar to simple data statistics, the samples collected by the SPC monitoring Kanban can also be different and the samples could combine at multiple angles according to time, order, material type, package type, etc.
5. Conclusion
This paper mainly focuses on the framework of the execution process monitoring technology for electronic assembly production. Firstly, it studies the execution process quality monitoring technology for electronic assembly production and the visual monitoring technology based on electronic assembly production instant Kanban. Then the corresponding system is designed to verify the correctness of the research in this paper, which successfully implements the application on the electronic assembly line system. This technology realizes the quality monitoring in the process of electronic assembly production with more intuitive and effective monitoring means, which improves the production efficiency, reduces the production cost and achieves the refined management goal of the production line.

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