The Design and Implementation of Information Management and Control System for Military Products Intelligent Assembly Line Based on JIT

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Abstract. To enhance the capabilities of advanced military product manufacturing, this paper carries out a new design and implementation of advanced military product assembly line. Through research on the current bottleneck problems and the aims of the production line, the system structure is designed and the function requirements are analysed to complete the software architecture design. Finally, the JIT information management and control system is completed based on information technology and lean manufacturing.

1. Introduction

In 2015, China’s State Council (CSC) released a strategic development plan for the Chinese manufacturing industry, called Made in China 2025 (MIC2025), which has the aim of enhancing the country’s manufacturing capabilities [1]. The manufacturing industry has subsequently accelerated the deep integration of advanced information and communication technology and the traditional high-tech, and has ushered in the rapid improvement of intelligent manufacturing.

With the implementation of the strategy of strengthening the army with science and technology, the demand of advanced weapons and equipment is increasing, however, the traditional low-automation production mode which the military production line adopts currently is inefficient and high-cost, so that it is gradually unable to meet the growing demand. Therefore, the primary problem needed to be solved firstly is transforming this traditional low-tech production mode into a modern high-tech one, through building a new efficient intelligent production line with high level production management system.

The manufacturing process of military products has the characteristics of order production, fixed project duration, and flexible production [2]. Meanwhile, the domestic military products production lines still have many problems because of using traditional production mode, such as low degree of automation, low production efficiency and high cost. The core idea of lean manufacturing is relentlessly work on eliminating waste from the manufacturing process. The just-in-time (JIT) manufacturing is suitable for the characteristics of the military products manufacturing process as mentioned above, and meets the requirements to reducing waste, responding quickly to production problems and providing data support for further improvement of production [3]. According to the study, this paper raises automation level of assembly line and upgrades management control system
for the assembly line through applying industrial Ethernet, intelligent logistics, sensors, and electronic Kanban technologies, etc. Finally, a high-level automated pull-type production line is built, which is designed based on JIT, and runs the information management and control system. By collecting and analysing the information about production plans, products, materials, quality, and equipment of the entire line, the information management and control system implements the functions of real-time status monitoring, process guidance, material management, quality control, equipment and personnel management, and production data management. Through querying, tracing and statistical analysis product data, line managers can monitor real-time state of the production process, solve the problem of line balancing, reduce production costs, improve production efficiency and further raise workshop management level. In this paper, the assembly line, as a kind of the production line, will be called as the production line following.

2. System Analysis and Structure Design
The traditional production mode, which is used by the production line, leads to lots of problems:

- Push-type production mode wastes a lot of storage sites for Work-in-Process (WIP) easily.
- Non-digital information management mode causes that line managers cannot find problems in the production process in time.
- Production tracking system have not been built. Line managers trace problems to root causes hardly.
- Unclear logistics routes lead to material accumulation, waste of site and transportation.
- There are plans to reform the current production line for solving the problems above:

  - Digitize the quality data, process data, personnel data, materials data, environment data, and equipment data of the entire production process by using information technology.
  - Plan the information flow reasonably.
  - Design the structure of information management system based on JIT.

According to the requirement analysis, all management and control equipment are connected through industrial Ethernet in the workshop. The system is divided into four parts: application layer, storage layer, transmission layer and equipment layer. The system structure is shown in Figure 1. These parts can be designed as follows.

- Application layer: the information management and control system application software implements all operations related to human-computer interaction, AGV control and management, and functions of JIT. The electronic kanbans real-time display production plans, production status and alarm information. The video monitoring system monitors and stores video information of each work station.
- Storage layer: the database and OPC server are set up in the server for the information exchange and data storage in the central control room.
- Transmission layer: the server, equipment and operation terminals transmit data via industrial Ethernet.
- Equipment layer: there are automatic equipment and operation terminals at all work stations to collect data to application layer and execute commands from information management and control system.
3. Function Analysis of System Application Software

The information management and control system sends production plans to all work stations, collects production status of each station, analyzes and displays the production information on the screen in the central control room and the electronic kanbans to line managers. According to the analysis of data flows of management mode based on JIT, there are four functions (as shown in Figure 2) that span across all production processes: plan release, data collection, data feedback, and data analysis.

- **Plan release**: line managers import plans into application software and release plans. The system analyzes the current plan and the production status of the line, then sends the information, including plan time, plan number, process guidance, material information, and quality control information, to each station, controls AGV to transport main component automatically at the same time. Workers at each station operate according to their own information.

- **Data collection**: equipment layer completes this function. It gets daily inspection data of environmental safety and equipment before production, and production time, quality, materials, personnel, and production problems by both automatic and manual data acquisition equipment at each station during the production process.

- **Data feedback**: real-time data is transmitted to the information management and control system through the industrial Ethernet. The system displays the production status and problems about personnel, quality, equipment and materials on screens in central control room and the electronic kanbans. Line managers can monitor the line and the exception handling process is started soon enough.

- **Data analysis**: the system uses the obtained data to create production files of each product for track and analysis of production information. Meanwhile, line managers can make statistics.
and analysis of process time, quality problem, materials problem, and so on, to provide data supports for further optimization of production.

![Diagram of Data Flows](image)

**Figure 2. Functions of Information Management and Control System**

### 4. Design and Implementation of System Application Software

According to function requirements analysis, the application software architecture of the information management system is designed, and is divided into application layer, interface layer and collection layer, as shown in Figure 3.

The collection layer works at all stations, calls for material, gets process data of personal, production exception, environmental safety, equipment, measurement, and gets PLC control results. In order to improve the line’s fault tolerance for AGV equipment fault and ensure the production smoothly, the position information of main component and the AGV logistics information are collected independently to make the production will not be delayed by AGV equipment fault.

The interface layer carries out the interaction and storage of production information by applying the database and OPC server in the server of the central control room. There is all information of the line, including production status data, control data, basis data, production process data, and statistical data.

The application layer is implemented by the system application software in the main industrial computer of the central control room. There are nine functional modules (as seen in Figure 3) of it: production status display, production plan management, AGV control, process file management, quality management, material management, equipment management, environmental safety management and personnel management.

- **Production status display**: line managers monitor the real-time status of the production line through the display screens in the central control room and the electronic kanbans in the workshop at the same time. The system application software displays status information in two levels. The first level is production schedule and alarm information in terms of quality, personnel, equipment, and materials. The second level includes the current information of product, workers, and man-hours used at each station, current tasks performed by AGV, etc. The electronic kanbans in the workshop display daily plans, monthly plan and detailed alarm information to all.

- **Production plan management**: there are functions about production plans, such as reception, release, adjustment and record. Line managers can query historical information of plans for information track or improving production efficiency.

- **AGV control**: the application software plans AGV operation tasks automatically according to the production plans and the current production line status to achieve main component intelligent transportation.
Figure 3. Software architecture of Information Management and Control System

- Process file management: the application software manages process files of all kinds of production on this line, including documents, pictures, operation instruction videos, etc. Workers at each station operate with their own plan and process files which are provided by the system, to ensure product quality by standardizing, regulation and modularizing the operation of workers.
- Quality management: at the quality inspection points of each process, the quality data of each product is collected, summarized and production quality reports are made to provide data support for line managers to trace quality problems and control product quality.
- Material management: the system calls the material supply for each station in advance according to the production plan, traces all materials entering the workshop, records the relevant information between productions and materials, and problems in distribution. It can provide data support for tracing material problems and improving material supply efficiency.
- Equipment management: the system manages all equipment’s daily inspection items, records and summarizes the results. Based on relevant usage and maintenance information, the system can remind equipment maintenance. It can provide data support for equipment managers on equipment maintenances and fault repairs,
- Environmental safety management: the system manages all environmental safety inspection items, and records inspection time, inspectors, inspection results in detail, to provide data support for ensuring safe production and risk reduction.
- Personnel management: the system manages all production-related personnel information, assigns the operation authority of personnel and sets up the job distribution of all stations, to
ensure that personnel information such as work time, operation quality, and problems in personnel production can be traced.

The information management and control system integrates production information, quality information, process information, material information, environmental safety information, and personnel information to ultimately improve the information management level and production efficiency of the production line.

5. Conclusions

Based on the study of lean production and information management technology, intelligent manufacturing is applied to the manufacturing process of military products, and a JIT intelligent production line information management and control system is built. It monitors production line status, manages product information, guides process, traces material information, controls main component transportation intelligently, etc. The production line of military products is raised the level of automation and informatization, to improve the production efficiency, reduce costs and labor intensity, and raise the production efficiency.

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7. References

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