Research and Design of MES System for Intelligent Production Line of Prefabricated Building Components

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Abstract. Due to the national mandatory requirements for building assembly rate, more and more production enterprises have invested in prefabricated building component production. Because of the low intelligence of production line and the lack of advanced production management system, the problems of component production in terms of standard, quality, efficiency and energy consumption are gradually revealed. Based on the information management, combined with the new generation of information technology, this paper studies the technology, functional requirements and system architecture of MES system of intelligent production line, in order to promote the fine management and information management and control of PC intelligent production line.

1. Introduction
Prefabricated concrete building is a concrete structure building designed and built by means of on-site assembly, mainly based on factory produced reinforced concrete prefabricated components. It has the remarkable advantages of fast construction speed, conducive to winter construction, high production efficiency, good product quality and low material loss [1]. At this stage, Chinese architecture has entered a period of high-quality development. The development of prefabricated buildings is an important measure for the industrialization of new buildings. At present, most prefabricated building component manufacturers still has a low degree of overall production automation, has poor coordination of design, production and construction, has defects such as low informatization level of plan management, process management and quality management. In view of this, the research and design of a set of MES system for intelligent production line of prefabricated building concrete components (abbreviation PC) has strong practical significance for enterprises to improve production efficiency and quality, realize fine management and information management and control [2-3].

2. Theory and system technology

2.1 lean construction theory
Lauris Koskela, a Danish scholar, proposed to apply the mature lean management of manufacturing industry to the construction industry in 1992 to improve the management level of the construction industry, and first proposed the concept of "lean construction" at the IGLC (International Group of lean construction) conference in 1993. Based on TFV (transformation flow value) production theory, the value flow in the production process is redesigned in order to shorten the construction period, reduce energy consumption and improve efficiency. Because the production of fabricated building parts is a system engineering involving multi-body, multi-objective and multi elements, it has the characteristics of high complexity, large investment and strict construction period requirements.
Therefore, making full use of lean management concept and modern information technology is of great help to the just in time production, concurrent engineering processing and efficiency improvement of fabricated building parts. As an important information system to promote the digitization of the construction industry, BIM can highly integrate all kinds of information elements of prefabricated buildings, and provide strong information technology support for the lean management of the whole life cycle of prefabricated building design, component production, logistics transportation, installation and construction. Through the establishment of 5D-BIM model, the accurate data of production progress, cost, quality and material consumption of prefabricated building parts can be connected and shared with MES system and ERP system, which lays a good foundation for the lean construction of prefabricated building.

2.2 MES system theory
AMR (Advanced Manufacturing Research) defines MES as "workshop-oriented management information system between the upper planning management system and the lower industrial control". MES system usually integrates management functions such as production scheduling, quality control, product tracking, equipment fault analysis and network report. It can provide accurate production data for production department, quality inspection department, process department and logistics department.

The construction mode of MES system under the background of industry 4.0 is different from the traditional mode. It is necessary to open the standard interface for information interaction between information systems, information systems and control systems and equipment, emphasizing vertical integration, horizontal integration and end-to-end integration [4]. Therefore, it is necessary to emphasize standards, openness and sharing at the beginning of system design. Otherwise, the efficiency and quality of the whole production system will be low, or even failure. PC-MES system connects BIM, ERP and other systems upward to realize the effective combination of automation and informatization; Downward connection of equipment control systems such as industrial fieldbus (profinet) and PLC plays a role of up and down.

2.3 Software design and development technology
Due to the customer's personalized demand for the production of fabricated building parts, it is appropriate to select the combination of prototype method and structured method for development.

It is of great help to improve development efficiency, practicability and meet customer needs. The system should adopt B/S architecture mode, which can realize multi-user remote access and control of the system, so as to meet the needs of modern intelligent management.

According to the site environment and the characteristics of the development team, J2EE or Microsoft. Net can be used for software platform development.

From the perspective of data transmission, the data transmission between MES system and other systems can be carried out in three ways: data exchange through data buffer, obtaining or pushing data through interface service call, and establishing enterprise data bus system.

The three methods have their own advantages and disadvantages. Compared with the form of service call and data bus, the coupling degree is lower. But the workload of secondary development is relatively large. In the application and implementation of large and complex enterprises, the integration of system interaction interface is often carried out in the form of enterprise data bus. In small and medium-sized enterprises, web service technology is usually used for information interaction services.

3. Design requirement analysis of MES system for PC component intelligent production line

3.1 Construction objectives of MES system in PC intelligent production line workshop
The MES system of PC intelligent production line workshop is used to manage the production plan allocation, production execution process management, workshop quality management, equipment management, process management, traceability management, equipment data integration, etc.

Combined with the actual production process of the component production workshop, the system
aims to realize the information-based management and control of the manufacturing process according to the process flow of bench mold cleaning, drawing lines, mold assembly, spraying release agent, reinforcement installation, embedded parts installation, concrete distribution, vibration and compaction, pre curing, roughening/troweling, stacking and warehousing, maintenance, formwork delivery, formwork removal, hoisting and storage in the storage yard. Intelligent scheduling and integrated operation support the integrated operation, real-time monitoring and intelligent decision-making of production tasks, manufacturing equipment, materials, quality and personnel, so as to achieve the objectives of flexible task scheduling, agile process control and scientific decision-making in the manufacturing process [5-6].

Through the implementation of MES system in the workshop of intelligent production line of parts and components, it is expected to achieve the lean production objectives of visualization of production status, traceability of production process and continuous improvement of production management.

3.2 Functional design of MES system in PC intelligent production line workshop
The MES system of PC intelligent production line workshop needs to get through the design production construction link, mainly including production information, quality inspection information, storage yard information, equipment information, etc. Through accurate calculation and release the production task at the corresponding time point. The system interfaces with various equipment and other related systems to achieve the purpose of automatic production through MES system. The specific functions are shown in Table 1.

| functional module | functional design |
|-------------------|-------------------|
| production plan management | production order import, production scheduling management, production order distribution, production order query |
| manufacturing process management | operation adjustment, material loading traceability, production execution work report, material bar code management, rework and repair management and scrap management |
| process management | product routing, operation management and product BOM information |
| production equipment management | equipment account management, equipment basic data management, equipment routine inspection record management, equipment maintenance record management, equipment fault maintenance record management and equipment OEE management |
| manufacturing life cycle traceability | plan and work order tracing, manufacturing process tracing |
| display board and statistical management | comprehensive statistics of display board and production in workshop |
| yard management | automatic searching and stacking of components |
| production quality management | quality basic data definition, IPQC quality management, statistical process SPC, quality defect management |
| integrated interface management | BIM/ERP system integration |
| system management | organization, plant modelling, system authority management, data backup management |
4. Analysis and design of MES system framework for PC intelligent production line

4.1 Software framework model of MES system in PC intelligent production line
Theoretically, the MES system of PC intelligent production line needs to open up the four levels of equipment layer, control layer, business management layer and operation management layer, so as to truly realize the goal of lean construction, continuous improvement, energy conservation and efficiency.

The equipment layer is generally composed of single hardware. The intelligent production line needs equipment equipped with RFID and QR code chips to realize the interconnection of equipment and system.

The control layer is responsible for accurate docking with the equipment layer, which requires the collection and integration of relevant data on the equipment layer, which is the basis for realizing the intellectualization of the production line.

The business management layer promotes the integrated application of PC intelligent production line management by integrating multiple systems such as manufacturing execution system (MES) and quality information management system (QMS).

The operation management level coordinates the whole process of production and operation, and guides the lean production of system at the business management level through ERP, BIM and other system integration. The four levels support each other and develop in coordination, as shown in Figure 1.

![Figure 1 MES system software framework model of PC intelligent production line](image)

4.2 Hardware architecture design of PC intelligent production line
The hardware investment is determined according to the actual needs such as the scale, capital investment and capacity demand of PC component manufacturers. Taking the campus PC intelligent production line of Chongqing College of Architecture and Technology as an example, the hardware architecture design is shown in Figure 2. One MES application server is deployed in the machine room for business processing and data storage related to MES core function applications. The workshop is equipped with eight sets of MES terminals (MES terminal includes PC, scanning gun and console), one touch Kanban, two PDAs and 1 label printer, which are used for production data acquisition and business operation of each process, including production plan query, work order execution, feeding information record, equipment fault cause entry, data statistical analysis, historical information query, etc.
5. Conclusion
PC-MES is a component-based enterprise intelligent manufacturing management platform. It is also an important platform to promote lean management and information management and control of PC component manufacturing enterprises. It can provide enterprises with production applications such as production dynamic management, real-time decision scheduling, equipment dynamic management, production early warning, quality management and so on. Only by opening up the MES system at the four levels of equipment layer, control layer, business management layer and operation management layer can we truly realize intelligent construction and lean management, and have extensive popularization and application value in the field of intelligent construction.

This paper puts forward the construction scheme of MES system of prefabricated building precast concrete component (PC) intelligent production line from the aspects of theoretical and technical basis, development objectives and functional modules, software and hardware architecture design of pc-mes system development, in order to provide ideas for MES system construction of PC component manufacturers.

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