Research and Design of Manufacturing Execution System in a Bicycle Smart Factory

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Abstract. Manufacturing Execution System (MES) is a production information management system for execution level of manufacturing enterprises. Manufacturing industry began to use computer technology, the implementation of automated operation management system, in order to improve economic efficiency, promote the further development of enterprises, occupy a certain position in the economic market. This paper combines the working characteristics and business processes of bicycle manufacturing plant, analyses the application and implementation methods of manufacturing execution system in bicycle manufacturing plant, designs the key modules of the system, and finally implements MES in detail.

Overall Design of MES

Introduction of Manufacturing Execution System

MES, the full name of manufacturing execution system, is a set of information management system specially used in industry execution production. The operation of such a manufacturing execution system in manufacturing can provide enterprises with management module such as manufacturing data management, scheduling management, plan scheduling management, Inventory management, quality control, human resource management, work center/equipment management, tool tooling management, purchasing management, cost management, project visual board management, production process control, underlying data integration analysis, Upper layer data integration decomposition and so on. Through the advanced information technology, computer technology and other sales departments to achieve an information management system. It is an optimization of the manufacturing process of the whole workshop, the interaction of skill-based information among the demand layer, the planning layer and the control layer, and the integration of enterprise information through the continuous information of the enterprise.

MES has the following characteristics: a. Using powerful data acquisition engine and integrated data acquisition channel data acquisition coverage of the entire manufacturing plant, to achieve real-time and accurate acquisition of comprehensive field data. It has good expansibility to build the basic platform for data acquisition of manufacturing plant production management system. B. With advanced technology, it has comprehensive and complete product traceability function. C. Real-time monitoring of production, Kanban management. D. Based on Microsoft. NET platform development, support Oracle / SQL server and other mainstream databases. The system is a combination of C/S structure and B/S structure. It is easy to install and update. Real-time, comprehensive and accurate performance and quality analysis SPC. E. Through WEB browser, real-time information of production site can be grasped at anytime and anywhere. Ensure rapid implementation and reduce project risk.

Requirement Analysis

Typical bicycle manufacturing process includes 10 assembly and debugging processes, each stage also includes a number of specific links, as shown in Figure 1. Field equipment can be divided into single automation equipment and traditional equipment. Single automation equipment includes industrial robots, packaging machines, AGV and so on. Traditional equipment is totally manual operation, time-consuming and laborious, and the production effect is not good. Single automation
equipment realizes automatic control and can automatically adjust parameters within a certain range, but not connected with other equipment and central control room equipment network, resulting in each equipment is an information island. In addition, there are also the following phenomena: the quality inspection of intermediate products and finished products are offline inspection methods, which have long detection time and single control means; the information of production records, clearance records, links between production links and bill of materials are all recorded and returned manually, and the data can’t be automatically collected and stored, which often leads to data disjoined. Real-time and traceability can’t be guaranteed; the utilization rate of production data is low, which can’t form decision support for in-depth analysis. With the gradual expansion of production scale and the deepening of intelligence, data sources and data volume will continue to increase. Achieving the full range and type of production data acquisition and storage, mining, analysis and visualization display on this basis, so that relevant personnel can quickly and accurately obtain the corresponding authorized production data, has become the most important requirement for bicycle manufacturers to apply MES.

**System Framework**

This data management platform is designed from data generation, data acquisition, data storage, data analysis, data application data life cycle, as shown in Figure 2. The platform is divided into acquisition layer, storage layer, analysis layer and application layer. Each adjacent layer can interact with data. The application layer feeds information back to the human-machine interface or directly acts on the field equipment through industrial Ethernet to form closed-loop feedback to ensure efficient and controllable production. The whole platform embodies the main line of data, information, knowledge and wisdom from bottom to top. It senses and obtains production data in an all-round and deep-seated way, associates isolated data, forms data resource pool, transforms data into information, transforms information into knowledge through intelligent analysis, and integrates knowledge and information technology to support various intelligent applications of rubber production.

The data acquisition layer is divided into two parts. It is transmitted to the server of data center and control room through standard industrial Ethernet or wireless network. For devices without Ethernet port, RS485 bus or bus to Ethernet module can be installed. After data acquisition, data is cleaned and integrated through data integration, and then stored effectively according to a certain logical relationship. At the same time, the management platform will also realize the registration and directory management of data assets. Data analysis layer is a hierarchy of analysis and mining of six...
kinds of data in storage layer according to the requirement of application layer for management and decision support of production environment. On the basis of manufacturing process database, data analysis builds a complex data relationship network with data as nodes and data correlation as edges according to attribute connection and topic correlation between data. According to the functional division of data analysis, data analysis methods can be roughly divided into dimension reduction analysis, classification and clustering analysis, correlation analysis and prediction analysis. This system mainly applies correlation analysis to establish independent correlation model and non-independent correlation model to provide theoretical methods and data support for upper decision support. Data application layer is the brain of data platform. The optimized standard data are shared and packaged, and the decision-making information of production management is generated from the four aspects of quality management, energy management, personnel assessment and product traceability by using the data analysis layer's data and functional interface and the knowledge of rubber production specific model. The decision-making information is fed back to the field equipment layer to continuously optimize production. As a one-stop service platform, it realizes the application of bicycle production intelligent factory.

![Data Management Platform](image)

**Key Module Design of MES**

**Information Management Module**

This module mainly manages some non-business and non-production data, such as user information management, user rights management and so on. User information management mainly includes the functions of assigning account number, entering employee information, modifying password and password retrieving. User authority management includes administrator authority, salesman authority, Sales Manager authority, production manager authority, production manager authority, senior operator authority, general operator authority, warehouse personnel authority, etc.

**Order Management Module**

When the customer orders, the salesperson is responsible for inputting information. If the enterprise goes online with SAP system, it can develop the corresponding interface, directly call the relevant data (other modules can also use this way if they encounter similar situations), and vice versa, directly input information. After the salesman enters the information, the order information will be directly pushed to the department manager who has the authority to audit. After the department manager checks and approves, the order information will be pushed to the production management department by the system. When developing this module, developers should include the following key
information: order number, customer number, product type, order quantity, order date, expected delivery date, salesman, audit manager and so on.

**Production Management Module**

After receiving the order information, production managers should draw up work orders in MES system according to the order information. When making work orders, they should fully consider the customer's requirements, current production situation, production scheduling needs, human resources and other related factors, and formulate the most reasonable production plan. After the production manager enters the information, the work order information will be directly pushed to the department manager who has the authority to audit. After the department manager checks and approves, the production department is ready to start organizing production. When developing production management module, developers should include the following key information: work order number, order number, planned production start date, planned production end date, production quantity, work order issuer, audit manager and other related information.

**Process Management Module**

This module is the core module of the whole MES system, according to bicycle manufacturing process setting process. After receiving the information of the work order, the production line manager prepares to organize production according to the start date of the work order. Before the whole production, the operator should do a preparatory work to paste the bar code marking the product identity (product ID) to the appropriate part of the product. This work is very important and must be done before production, otherwise some data will not be collected. The process characteristic of bicycle production is that some processes can be executed by jumping, and all processes cannot be executed at the same time.

**Quality Management Module**

After receiving the information, the quality assurance personnel can arrange reasonable time for inspection according to the actual situation of the work. At this time, if the product has completed all the production processes, the system prompts to start the inspection. On the contrary, if the product has not completed all the production processes, the system prompts that "if the production process is not completed, please return to the production line", and the quality management module of forbidden goods cannot carry out quality inspection.

**Data Acquisition Module**

Data acquisition based on PLC system is the most important acquisition mode in the field of automation production. For various reasons, it is impossible for factory automatic control equipment to adopt one product, while manufacturers of different equipment often adopt their own fieldbus technology due to their respective interests and technical limitations. According to the seven-layer OSI communication model, the current standard industrial Ethernet adopts TCP/IP protocol in the transport layer and below based on the standard of IEEE802.1-IEEE802.11. However, there is no unified standard above the transport layer, such as session layer and application layer, which leads to the interconnection but not interoperability between devices using different industrial ether net, that is, the data and instructions transmitted by each other cannot be identified. In addition, system programming software and configuration software are tightly bound to hardware. Hardware and software cannot be mixed among different manufacturers, which causes great trouble to system integration, spare parts and personnel training. In view of this, the system uses OPC-UA communication standard to collect part of the data in order to achieve data exchange and semantic exchange between devices and information systems.
System Implementation

Database Implementation

For the complexity of field data, there are not only sensor data of different units and ranges, but also manual data input through human-computer interaction interface and other types of data. In order to achieve unified management, data must be sorted out and divided, and standardized data logical model must be established according to various data types and formats. The data processing logic is shown in Fig. 5. When the data acquisition equipment in each process sends the data update signal, the database receives the data and decides whether the data is received or not. If it is judged that the reception is complete, the data will be checked. If it is judged that the reception is not complete or that the data has not been received, it will return to the previous state and be ready to receive the data. After receiving the data, the validity and integrity of the data are checked to determine whether the verification is successful or not. If the verification is successful, the data are processed and stored. Otherwise, the data is considered illegal, and the program ends and returns to the start state. From whether the data is received to the end of the program, each process is recorded in the log for data storage and data repair.

Implementation of MES.

The bicycle MES system uses JAVA language for background development, and MySQL is used for database development. Finally, the development of MES software is realized. The main control interface of the system is shown in Figure 3. It presupposes ten functional modules, including equipment management, personnel performance management and production planning management. The software is installed in the control room, and different privileges are assigned according to different positions to ensure the safe and stable operation of the software.

![Figure 3. The main control interface of the MES.](image)

Discussion

This paper designs a bicycle intelligent production data management platform based on MES, aiming at the need of intelligent transformation of bicycle production enterprises. The problems of what kind of data to collect, how to collect data, data storage mode and data application are discussed. The effective management and intelligent application of field data are realized, which can be used for reference in the intellectualized transformation of rubber making enterprises. The next step is to fully absorb the latest technologies of Internet, big data and artificial intelligence, combine with actual production, screen the parameters that affect quality indicators, use advanced algorithms, constantly optimize the weight of parameters, establish a data-driven quality online detection model, improve production efficiency and product qualification rate.
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