Information model construction of MES oriented to mechanical blanking workshop

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Abstract. Manufacturing Execution System (MES) is one of the crucial technologies to implement informatization management in manufacturing enterprises, and the construction of its information model is the base of MES database development. Basis on the analysis of the manufacturing process information in mechanical blanking workshop and the information requirement of MES every function module, the IDEF1X method was adopted to construct the information model of MES oriented to mechanical blanking workshop, and a detailed description of the data structure feature included in MES every function module and their logical relationship was given from the point of view of information relationship, which laid the foundation for the design of MES database.

1. Introduction

The blanking is the first process in product or parts manufacture, which is also the critical process influencing the production and products’ quality. The mechanical blanking workshop, which is in the upstream of the part flow, is not only the initial link of the production chain, but also an important link of influencing the production and products’ quality [1]. As the production task execution layer in manufacturing system, the mechanical blanking workshop plays a connecting role in material flow in the manufacturing system. On the one hand, it receives the production task from the upper management system in the enterprise, executes the task according to its own balance and capacity requirement and prepares for the following processing. On the other hand, it makes standardized management to the workshop resource and production status information according to the requirement of departments in the enterprise, which can ensure the smooth blanking production.

Building manufacturing execution systems (MES) oriented to mechanical blanking workshop is a key link to implement informatization in manufacturing enterprises, and it can not only improve the efficiency for workshop production and create economic benefit for the enterprise, but also play a driving role to the entire business management level [2, 3]. Therefore, construct the information model of MES oriented to mechanical blanking workshop on the base of analyzing its manufacturing process information and information demand is one of the key works in MES development and realization.

2. Manufacturing process information of the MES

As a management system oriented to mechanical blanking workshop, the core of MES is to implement the overall management of the production job, material, quality, workshop equipment, personnel and other key elements in the manufacturing process, support and realize visualization, real-time and transparency of the blanking process, which can realize the lean management in the entire production line.
manufacturing process for the enterprise [4]. Therefore, MES must closely connect the top layer plan in enterprise and the bottom layer production to ensure the smooth workshop production. The complete activity chain of the manufacturing process information between different function modules in the MES is shown in figure 1.

The production planning department in the enterprise firstly assigns production task to the blanking workshop according to the master production schedule in the upper-layer ERP, and the job planning and scheduling module searches the relevant information from the drawings/documents management module after accepting the task, makes process planning and sends the working procedure of preparing the blanking procedure to the NC procedure management module.

After obtaining the whole information needed for the job planning, the job planning and scheduling module makes a group of job planning and resource allocation instructions oriented to the workplace. Under constraint of resource condition of material, equipment, personnel, procedure and production condition of process, delivery date, batch quantity, etc., the planning and instructions need to optimization sequencing according to the process turnover time and clamping auxiliary time [5]. The sequenced job planning is confirmed by the workshop scheduler, and then converted to the production ticket and sent to the worker to execute the blanking production. When the specified job in the current production ticket is finished, the worker needs to feed back the production ticket recording the relevant manufacturing information to the job planning and scheduling module. Meanwhile, the feedback production tickets are confirmed by the workshop inspector and sent to the performance analysis module to make statistical analysis, generate the report data including the feedback information to ERP, the statistical report of every worker’s attendance and work hour, the part’s manufacturing process report, and so on. The quality management module detects and analyses the correlation data, and gives the product error distribution, the variation trend of the system error, the cause of the random error, etc., which can provide the necessary basis for eliminating error timely and improving the product’s quality. During the blanking process, the bottom control system real time collects the running state data of equipments, and feeds the data back to the performance analysis module to obtain the operating rate, the actual utilization ratio and history operating data of each equipment. It not only provides necessary basis for making the following job planning, but also provides important reference information for maintenance of the equipment.

3. Information model construction of the MES

Information model is the foundation of database design in MES development, and the purpose of construction system information model is to provide a consistent definition of the data meaning and
their mutual relation, and detail describe the structure feature of the data in the function modules from the point of view of information relationship, which can ensure the integrity of the integrated data, shared data and management data [6, 7].

3.1. IDEF1X modeling method

IDEF1X, a modelling technique for semantic data, is to apply the E-R (Entity-Relationship) method to the semantic data model to construct system information model [8]. The elements of IDEF1X mainly include: (1) Entity, including independent marking entity and subordinate marking entity. (2) Relationship, including calibration connection relation, non-calibration connection relation, classification relation and non deterministic relation. (3) Property / Keyword, including main keyword, creating keyword and exotic keyword. In the IDEF1X model, the rectangular box is used to represent the entity, the connecting lines between rectangular boxes are used to represent the links between entities, and the property names in the rectangular box are used to represent the entity attributes, as shown in figure 2.

![Figure 2. Basic structure of IDEF1X model](image)

Using IDEF1X method to construct MES information model has many advantages compared with the traditional E-R method, which are mainly shown in the following aspects [9]: (1) IDEF1X semantic model is more abundant and precise and it can fully and clearly express the data information of the system and its connection; (2) IDEF1X model has the better consistency and higher degree of standardization; (3) The logic model defined by IDEF1X is more beneficial to convert into the physical model.

3.2. Information model of the MES

According to the established manufacturing process information in the MES oriented to mechanical blanking workshop, the entity analysis of the data information and its logical relationship was provided based on the characteristics of computer information processing, and IDEF1X modeling method was utilized to construct the information model of the MES every function module.

3.2.1. Information model of the fundamental data management module

The fundamental data is mainly static data, and its characteristics are that the data is stable in quite a long time and it is often queried and used. The information of fundamental data is usually the attribute information of the independent entity in the database design, and it is generally set as read-only in the application program. The fundamental data mainly includes product data information and workshop resource information. The product data information also mainly includes product BOM (Bill of materials) information and blanking process information, and its information model is shown in figure 3. The entity Product Assembly Drawing and Part Drawing generate the part detailed information (including the detailed information of homemade parts, standard parts, cooperation parts and purchased parts) according to the product structure configuration rule. The entity Part Detail, which is the basis for calculating the part work-hour, describes the structure size information of the blanking part. And the entity Part Detail and Calculate Work-hour are used to make the blanking process. When the part blanking mode is determined as NC machine processing, the technologist in the blanking workshop makes the relevant NC program according to the blanking process. Therefore, the uncalibrated relationship between the entity Blanking Process and NC Program is formed. The workshop resource information, whose information model is shown in figure 4, mainly includes material information, personnel information and equipment information. The entity Material describes the material name, specification, number and other information, which including the relevant entities Material Batch and Material Inspection. The entity Personnel, which is the decision-maker and executor of the blanking production system, describes the basic information and functional role of the
workshop personnel. And the entity Equipment describes the equipment’s basic parameters, status data, maintenance record and other information.

3.2.2. Information model of the job planning and scheduling module

The information of the job planning and scheduling is mainly the dynamic data in the blanking production, and its characteristics are that the data is changed constantly along with the time, which reflecting the status of the object at a certain time. The information of the job planning and scheduling is usually the attribute information of the dependent entity in the database design, and it is generally maintained dynamically in the application program, which supporting the transaction processing with user interaction. It includes production execution data and production monitoring data, and the former, whose information model is shown in figure 5, describes the executing information of the production order in the process from assigning production task, making job planning to completing the blanking production. The entity Production Planning, generated by the contract orders, decomposes the production task, makes the job planning and generates the entity Production Ticket to guide workers in blanking operation. The entity Blank Quality Inspection feeds back the quality inspection information of the parts to the entity Production Ticket, and generates the entities Reject Record and Warehousing Record. The entity Blank Production Preparation Report records the production preparing information of the materials, blanking process and equipments in the workshop, and it along with the entity Production Unexpected Situation Report describe the influence on the job planning.

![Figure 3: Information model of the product data](image1)

![Figure 4: Information model of workshop resources](image2)

![Figure 5: Information model of product executing](image3)
Production monitoring information records the relevant information in the blanking production process, including the job progress information, the collecting information of production resource state, work-in-process information, production unexpected situation, and so on. And its information model is shown in figure 6. The entity Blanking Process Data describes the information of work-hour, job process, inspection records of the blanking quality, material consumption, personnel status and equipment operation in the production process [10]. The entity Work-in-process Record describes the basic information of the work-in-process, including its process state, processing equipment, operator, quantity, actual starting/completing time, and so on. All of these information reflect the actual blanking processing course.

3.2.3 Information model of performance analysis module

Performance analysis information is mainly the middle data formed from statistical computing and analyzing the raw data source of the above static data and dynamic data. It is obtained and printed by the system program, and its output form is usually the statistic report in the database design. It contains the information of the blanking quality management module, and mainly performs a statistical analysis on the blanking production data of the order product to optimize the workshop blanking production. Its information model is shown in figure 7. The entity Personnel Attendance Statistics records workers’ information of attendance/absence, be late/leave early, work overtime, and so on. The entity Work-hour Statistics records the actual work-hour of the workshop worker and processing equipment in the blanking production. The entity Equipment Data Statistics records the equipment running time, rate of the equipment utilization, equipment fault time, fault causes and treatment measure. The entity Blanking Quality Analysis records the information of finished/waste parts quantity, the existing quality problems and improvement measure. The entity Blanking Cost Analysis records the input/output quantity of the parts and material consumption, and analyzes the material utilization rate based on the cost and expense. The entity Blanking Progress Analysis records the actual blanking processing schedule, which is used to improve the blanking job planning.

4. Conclusion

The research and development of MES oriented to mechanical blanking workshop is the first step for the enterprise information management towards the workshop information management, and it is the key link for realizing enterprise production data sharing and optimization of the workshop management [11]. Meanwhile, it constructs an effective platform for other workshop to implement MES system. Adopt the IDEF1X semantic modeling method to carry on the data modeling of the MES oriented to the mechanical blanking workshop, and perform its requirement, logical and physical design with the modeling tool, which can fully ensure the consistency and integrality of the data, realize the organic combination of the database analysis, conceptual model design and physical database structure design, and greatly improve the development efficiency of the MES.

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