Research on MES-based production process control system for discrete manufacturing enterprises

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Abstract. In order to solve the problems commonly existing in discrete manufacturing enterprises, such as unreasonable placement of production resources, difficult fine management and control of production process, and impromptness of workshop information transmission, it is urgent for enterprises to implement manufacturing execution system to strengthen the ability of production process management and control. Therefore, based on the actual production situation of discrete manufacturing enterprises, this paper constructs the production process control system architecture of this type of enterprises and studies the key architecture. Finally, taking X company as an example, after the implementation of this system, the inventory occupancy rate is reduced by 13%, the average transit time of products in process is shortened by 11 days, the waiting time of the workshop is shortened by 1.4 days, the production statistical table cycle is shortened by 3 days, the quality statistical table and the working time summary table are shortened by 4.5 and 1.5 days respectively.

Keywords: manufacturing execution system; discrete workshop; production process control; informationization

1 INTRODUCTION

With the increasingly fierce competition in the market, manufacturing enterprises are changing to a multi-type and small-scale discrete manufacturing model, which makes the production process easily affected by the external environment, and the probability of unexpected events is greatly increased, resulting in the management of workshop resources is often more difficult. In order to improve the overall management level of enterprises and thus enhance their competitiveness, manufacturing enterprises have started to introduce advanced management systems, of which MES is one of the key links [1]. MES is a production management information system for the executive level of the workshop, and is a bridge between production and management. It is an effective management solution to solve the production problems faced by discrete enterprises, such as improving production efficiency, reducing inventory, rationalizing resource utilization and reducing cost.

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2 Analysis of production processes in discrete manufacturing companies

2.1 Analysis of production status of discrete manufacturing enterprises

To improve the production process control capability of discrete manufacturing enterprises, we need to focus on analyzing the current production status of the enterprises and finding the current problems. According to the analysis of field research, the current production status of this type of enterprises is shown in Figure 1 below.

2.1.1 Production scheduling chaos

The production department schedules production according to the production plan so that production scheduling remains somewhat flexible, but there is still the problem of inefficient scheduling[2]. Managers are not informed of what is happening in the production process, so it is difficult to make real-time adjustments to production industries, raw materials, etc. Production planners are not able to grasp the real-time production situation and receive timely feedback on the implementation of the plan, and therefore cannot issue timely adjustment orders [3].

2.1.2 Difficult to fine-tune control of operational processes

The proper conduct of the production process requires selecting the right processing equipment at the right processing time, using the right process for the right batch, ensuring the smooth operation of the production line, and minimizing processing and operational errors [4]. At present, discrete manufacturing companies generally adopt manual statistics for production process information, which is inefficient and has a high error rate. There are many unexpected situations in the workshop, which are difficult to control in time, and the production process is characterized by frequent borrowing and mixing of materials and high staff turnover.

2.1.3 Frequent product changes

Due to the many types of production, frequent changes in production procedures, and the introduction of new products from time to time, the production process is prone to errors in mold installation, confusion in production information records and disorderly storage of products, which increase unnecessary production costs and reduce the productivity of the workshop.

2.1.4 Equipment not at maximum use value

In the production process, the stable operation of the equipment is also the key to improve productivity. The enterprise does not specify a regular maintenance plan for the equipment, and the data information of the equipment is recorded manually, which has a high error rate and low reliability, and the equipment cannot be automatically warned when a failure occurs [5], which needs to be handled by the operator.

2.1.5 Poor production information transfer

Due to discontinuous production and untimely information transfer, defective products may flow from the previous process to the next process, which affects the normal production work.

Production staffs need to ask for reports when there is an unexpected situation in the workshop, which leads to interruption of production work and thus reduces production efficiency. Managers are unable to understand the real-time production situation in the workshop and cannot manage the workshop in a timely and effective manner [6].

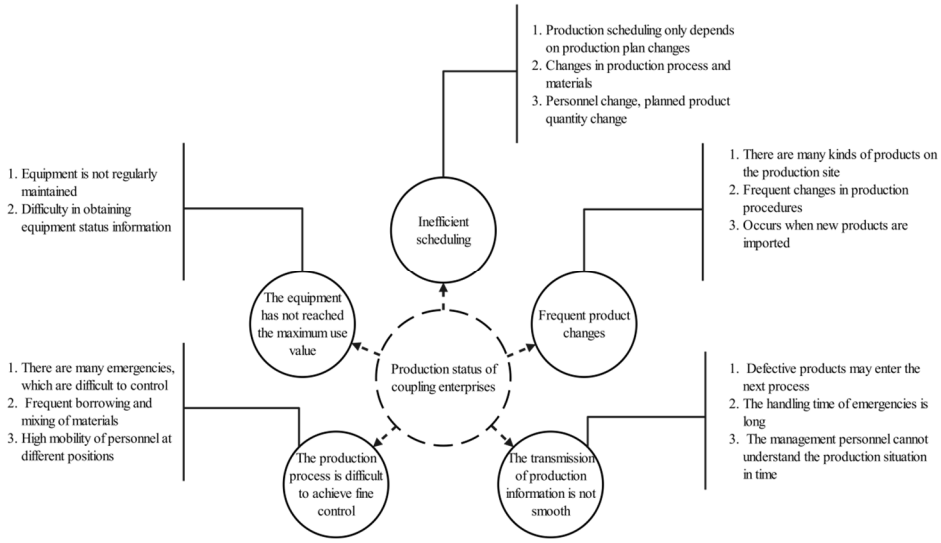


Figure 1. Production status of discrete manufacturing enterprises

2.2 Discrete manufacturing enterprise operation process construction

In order to introduce the position of MES in enterprise information management, here is an analysis of the enterprise of the author's MES project in real time, and a flow chart of the operation of the discrete manufacturing enterprise is constructed, as shown in Figure 2 below.

2.2.1 ERP layer

Production planners specify the master production plan based on market forecasts and customer orders. After the plan is imported into the ERP system, material decomposition of the product is carried out under the guidance of the data, and calculations are made taking into account factors such as inventory information and product information to develop the production plan and procurement plan [7].

2.2.2 MES layer

The workshop planning layer accepts the master production plan issued by the enterprise ERP system, and then makes the workshop plan according to the actual production situation and personnel information of the workshop and releases it. Workshop planning is specifically divided into material demand and dispatch demand, production personnel accept the work order and material delivery to start processing.

2.2.3 Control layer

The production process needs to be reported according to the processing situation, and the content of the report includes equipment information, material information, personnel information, quality control information and work order information. The control layer emphasizes the control of the actual production situation, real-time monitoring of the storage status of materials, the processing status of materials, the completion status of work orders and the specific parameters of quality control, etc [8].

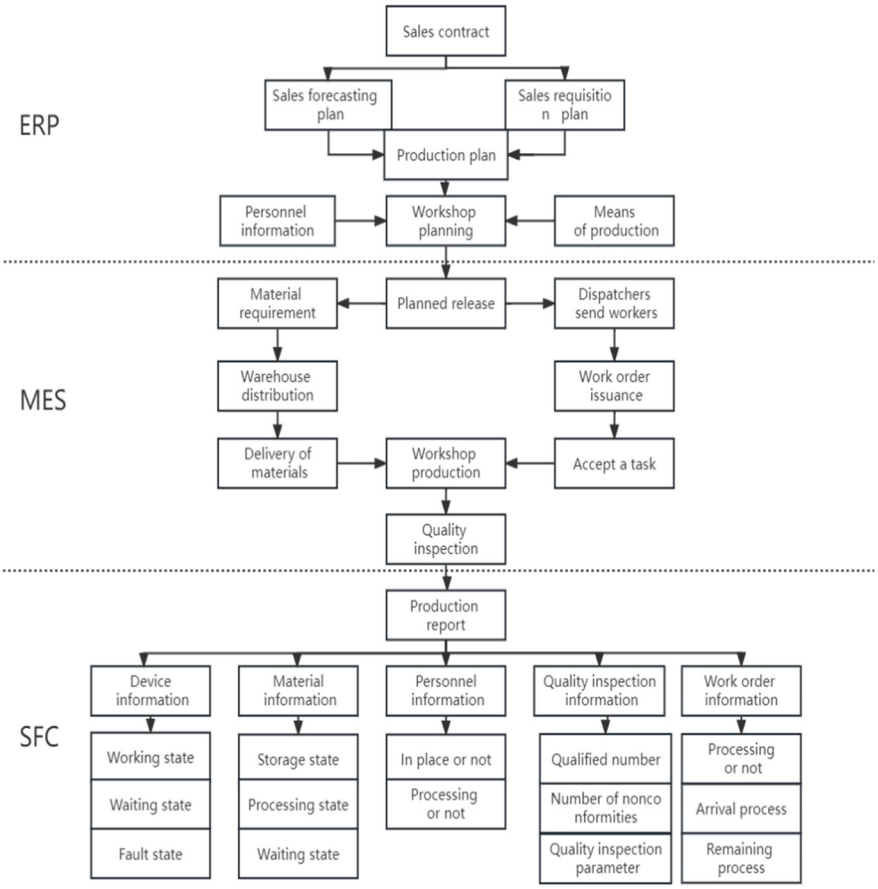


Figure 2. Discrete manufacturing enterprise operation process

As can be seen from the above construction of discrete manufacturing enterprise operation process, MES system is a bridge between the planning management and the bottom control, filling the gap between the two. MES can not only refine and decompose ERP production management information, but also accurately transmit operation instructions to the bottom control workshop. It can also monitor the bottom upgrade production situation in real time to ensure the efficient operation of production.

3 Design of discrete workshop production management system based on MES

3.1 Discrete manufacturing shop MES platform functional modules

MES is not only a separate function, but also has the function of supporting, guiding and tracking the production data, combining with the actual production management to build the basic data, product management, production operation, equipment management, process management, personnel management and other module functions. MES is not only a separate function, but also has the function of supporting, guiding and tracking production data;

Basic data: Through MES system collection from production personnel, machinery and equipment and the bottom control operation data as well as process, material information, production workers and management personnel can query semi-finished products, finished products, material storage and related production data[12].

Product management: Through the MES system, we record the quality information of each batch of product production process. The system can record a series of production data such as output, scrap, production serial number, raw material batch, mold serial number, etc., providing reference production information for subsequent production, providing a clear path for product quality tracing and strengthening product quality supervision.

Production operation: The production tasks are delivered through the MES system, the required materials, equipment and production operators are allocated according to the plan, and the actual production data is recorded by the MES system in real time during the production process. Automation determines whether there are operation errors, wasted materials and operators not at their workstations.

Equipment management: According to the equipment information in the system, the production plan and the actual production quantity of the equipment can be queried for the day, providing clear data for production operators and managers and facilitating the adjustment of production plans.

Work process management: According to the production process of products, MES system input data, automatic assistance to control the production process, can be combined with the automation of management functions and production process management, automatic traceability of work order.

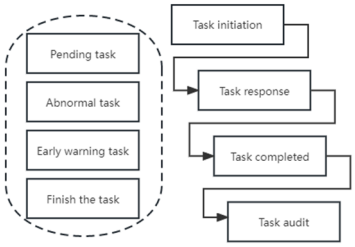
Personnel management: Through MES system, equipment, products and personnel in the workshop are linked together to provide staff status information data, so that managers can monitor workshop production status in real time and adjust production plans based on changes in business needs and production conditions.

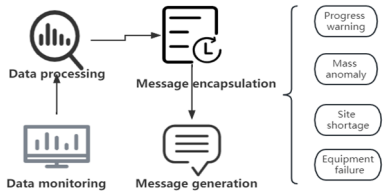
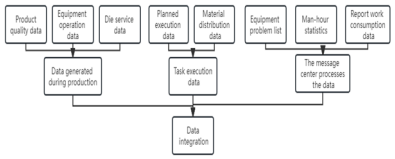
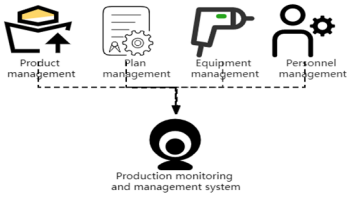
3.2 MES-based production system architecture for discrete manufacturing enterprises

In the case of a full analysis of the current situation of discrete manufacturing enterprises, in order to solve the problems faced by such enterprises, improve market competitiveness, and enhance the level of enterprise information management, this paper establishes the system structure of the production process control system for discrete manufacturing enterprises, and changes the architecture to mainly include resource identification, processing process, service

layer, message center, data integration, and application in six aspects, as shown in the below(Table 1).

Table 1. Production system architecture of discrete manufacturing enterprise production plans based on changes in business needs and production conditions.

System	Mode	Example image
Resource Identification	Database creation using dedicated hardware, RFID, scan guns, 1D codes, 2D codes, XML, CSV, PDF, etc.	  Hardware facilities diagram Scanning gun
Processing	It is the organic integration of the software and hardware equipment and production affairs related to the production plant	  Machining Center
Service Layer	In the production process, response events are processed in the form of service architecture, tasks are divided into pending tasks, exception tasks, warning tasks, and completion tasks, and the execution process is divided into four types: unresponsive, responded, completed, and in approval.	 Task process control

News Center	Monitor abnormal data in the production process, early warning data in the production process, and production data after the completion of production, and send the data to the corresponding system for analysis and processing.	 News Center
Data Integration	Analyze and process the data collected in production (product quality data, plan execution data, equipment operation data, mold problem list, reported work consumption data, etc.).	 Data Processing Center
Applications	According to the needs of the production process of manufacturing companies, the collected data is processed to build a real-time monitoring and management module for the production process.	 Real-time monitoring and management system

3.3 MES key module algorithm analysis

The material process state analysis algorithm of the NTH process is as follows: First, determine the field value D of the NTH process, D=n-mod (n,32) (Note: mod (a, b) represents the remainder of certificate a divided by integer b), then

$$\mathcal{V}(\mathcal{D})_{s} = \mathcal{V}(\mathcal{D})_{s} + 2^{n-\mathcal{D}}$$

V(D)S is the process state value of the material domain D, first calculate the domain value of the NTH process D=n-mod (n,32), and then calculate $V(D)_S/2^{n-D}$ to get the module m. If m is even, then the NTH process is not completed; if it is odd, then it is completed (Mo,2003) .

4 MES system implementation effect analysis

Taking X discrete manufacturing enterprise as an example, the system has achieved significant results since its operation for half a year. The improvement of workshop production process management is mainly reflected in the following aspects:

4.1 Improvement of production planning and control

The operation of this system effectively improves the management of work-in-process, and the average transit time of work-in-process is shortened from 36 days to 25 days. On the whole, the inventory occupancy of raw materials and semi-finished products is reduced by 13%, and the average monthly waiting time of the assembly workshop is shortened from 3.6 days to 2.2 days. The application of workshop production management system makes the abnormal in the production process get timely response, and the production planning department can more accurately adjust the progress and rhythm of parts manufacturing.

4.2 Improvement in information feedback and production statistics

Before the implementation of this system, the receiving and sending team would freeze materials on the 1st day of each month, and it would take two days to collect and correct the data, and then report it to the statistician of the branch factory. The statistician of the branch factory would spend another day to collect and summarize the data and generate a form, and finally report it to the production department and other departments on the 4th day of each month, with a statistical cycle of four days. After the implementation of the system, the statistical period is shortened to one day, and the production statistical report can be submitted every half a month, avoiding data errors caused by the inconsistency of statistical time points.

The statistics of production quality originally needed two days for the inspection team to copy the qualified numbers by hand and two days for the quality personnel to summarize and analyze the data. It took about five days to submit the quality statistical statement. After the implementation of the system, the quality statistical table could be submitted within half a working day.

The summary of working hours originally requires the team leader to collect the working hours receipts of the workers and submit them to the labor and capital of the branch factory for summary after confirmation. The statistical cycle is two days. After the implementation of the system, the labor and capital can submit the working hours statistical table within half a working day.

5 Conclusion

This paper takes the workshop of discrete manufacturing enterprises as the research object, in order to improve the workshop production process management level, analyzes the production status and existing problems of the enterprise, analyzes the important role of MES in the operation process of this type of enterprise, builds the production process control process architecture based on MES and analyzes the key modules. Taking X enterprise as an example, after the implementation of this system, The inventory occupancy rate was reduced by 13%, the average transit time of products in process was shortened from 36 days to 25 days, the waiting time of the workshop was shortened from 3.6 days to 2.2 days, the production statistical table cycle was shortened from 4 days to 1 day, and the quality statistical table and working hour summary table were shortened from 5 days and 2 days to half a working day respectively.

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