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Research on Integrated Control and Evaluation System of Manufacturing Workshop

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Abstract

With the transformation and upgrading of manufacturing industry, it is of great significance to study how to effectively control and evaluate the manufacturing process for the transformation and upgrading of manufacturing industry. Based on Computer Integrated Manufacturing System (CIMS), this paper first proposes a digital workshop management and control mode with six layers including generalized device layer, data access layer, information bus, model layer, KPIS and view layer to control the system. Then the workshop KPI evaluation system and its evaluation method based on organizational structure view are established by using the critical success factor method and value tree to support the integrated management and control system of digital workshop. It provides ideas for the integrated control of manufacturing workshop.

Keywords

CIMS; Integrated Control; Organizational Structure View; The KPI Evaluation.

1. Introduction

As a traditional manufacturing power, China has made great progress in technology and other aspects after a rapid development stage. At present, it is transforming into a manufacturing power. Intelligent manufacturing is the main direction of China's manufacturing transformation and upgrading. Under the background of intelligent manufacturing, the interconnection of massive, multi-dimensional, high-frequency and real-time information in the digital workshop has become a new feature of the workshop under the new background. We should strengthen the information exchange ability and control ability of the manufacturing workshop, so as to provide real-time and efficient management basis for management decision-makers.

2. The CIMS Application

2.1. Overview of CIMS System

CIMS is the degree of automation of different integration of multiple subsystems, such as management information system (MIS), manufacturing resource planning system (MRP II), computer aided design system (CAD), computer aided process planning (CAPP) system, a computer aided manufacturing (CAM) and flexible manufacturing system (FMS) and numerical control machine (NC, CNC), robots, etc. CIMS is developed on the basis of these automation systems. It realizes information integration and function integration of various automation systems through computers according to the needs and economic strength of enterprises[1].

CIMS regards the manufacturing system as a whole, and closely links the production, management and various links of the enterprise from the perspective of the system, so that the operation of the enterprise is more efficient and coordinated, and the development is more sustainable and stable [2]. With the rapid development of information technology, CIMS (Computer Integrated Manufacturing System) has been applied on a large scale. At present, CIMS is being gradually promoted in China, and the enterprises applying CIMS have gradually

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expanded from a few enterprises in the 1990s to various industries such as machinery, electronics, petroleum, textile, chemical industry, aerospace, metallurgy and so on [2]. In order to save logistics costs and improve efficiency, some enterprises begin to use CIMS for information management construction [1].

2.2. Dilemma Analysis of Workshop Management

There are some problems in data, information collection and real-time control in the digital workshop. For example, differences in the types, formats and semantics of information among devices make it difficult for data interconnection among devices to produce "information islands". In the context of Internet + Internet of Things, there will be a huge amount of data in the workshop. If not used, the data will lose its own significance. If used, it will involve data cleaning, filtering, gathering and extraction of impurity data and other issues. In the context of intelligent manufacturing, the coordination and information flow among multiple organizations become more complex, and how to conduct global control across organizational boundaries is another big problem faced by managers.

2.3. Use CIMS to Solve Problems

A function of manufacturing enterprises, each function is connected, and restraining each other, and can be divided into enterprise layer (responsible for dealing with the external and internal environment of the relationship between the factory and strategic planning), factory layer (relating to the production process, resource management and product design plans) and shop floor (relating to the activities in the actual production products) three levels [3].

In order to solve the above problems, this paper proposed to build the digital workshop integrated management and control system based on CIMS, and put forward the digital workshop KPI evaluation system based on the organizational structure view to support the integrated management and control system of the manufacturing workshop in the workshop layer (involving various activities of actual production products).

3. Propose the Integrated Control System of Digital Workshop

In order to realize the real-time, transparent, dynamic and systematic management of the digital workshop, there are still many problems. In order to solve the above problems, this paper proposes an integrated management and control mode of the digital workshop. Its structure is divided into six layers, namely: device layer, data access layer, information bus, model layer, KPIS, view layer.

(1) Device layer: Device layer is to encapsulate the device. The device layer is the source of data and the unit from which data is generated. It can be a specific physical device or any other unit that can generate data.

(2) Data access layer: the data access layer encapsulates, packages and abstracts the data accessed by the device layer. Some of the data collected from the device layer are unstructured and heterogeneous in structure. Therefore, it is necessary to normalize the data of these different attributes and use a unified structure to represent them. Here, a method of encapsulating stored data based on key-value pairs is proposed [4].

(3) Information bus: the information bus is the main data trunk of the integrated control system, through which software interacts with data. The information bus layer transmits massive data to the model layer through message queue technology [5].

(4) Model layer: the model layer contains many models such as order model, progress model, inventory model, etc. These models monitor and analyze the data transmitted from the information bus in real time through message queue technology, and feed back the analysis results to the information bus. In addition, the model layer will build various models according

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to time, space, quantity and state to form models such as order, schedule, inventory, capacity, quality and production line, and classify the data to facilitate the calculation of numerical results by the KPIS layer.

(5) KPIS layer: KPIS layer shall form KPI structure by classification according to the characteristics of each model in the model layer. KPIS is essentially a set of data, calculated from the KPI structure and basic data, and presented the calculated results to the view layer.

(6) View layer: the view layer is the view structure presented to the manager. Through the data presented in the view layer, the manager carries out integrated control over the enterprise, so that the global manager can intuitively and clearly understand the internal real-time state of the digital workshop.

4. Construction of KPI Evaluation System Based on Organizational Structure View

As mentioned above, many enterprises have applied CIMS for management in order to overcome the obstacles of information exchange and improve the ability of information management. Despite the complex CIMS information relationship, form a complete set of equipment, the investment intensity, the more complex technology, long development period, especially some key technologies are not mature enough, but it makes the emergence of corporate leadership decision-making more scientific and more quick, can enhance the response speed of the product on the market, such as delivery time, reduce cost and ensure the quality of comprehensive ways to enhance the enterprise competitive ability [3]. In order to verify whether CIMS has a significant positive effect on improving the competitiveness of enterprises, this paper proposes to establish a KPI evaluation system based on the organizational structure view (quality, delivery time, cost) to evaluate the integrated control system.

4.1. Design Ideas

According to the actual situation, the key success factor (CSF) [6] method is adopted in the design of the digital workshop KPI evaluation system based on the organizational structure view. In terms of KPI evaluation, CSF is generally used to find the key links that determine the success or failure of an enterprise, and then further refine the key links to obtain the key factors of the key links, so as to obtain the corresponding KPIs. The specific ideas are as follows:

(1) Determine the key link: that is, the digital workshop factory-level KPI. Drawing on the idea of critical success factor analysis, for digital workshop, cost, quality and delivery time are the three dimensions that factory managers pay the most attention to. Therefore, these three indicators are taken as factory level KPIs.

(2) Determine the key factors of key links: Decompose factory-level KPIs using value tree logic tools. The three factory-level KPIs, cost, quality and delivery time, were subdivided according to the key factor method.

(3) Determine the key KPIs of each key factor. Referring to the KPI set in ISO22400, the key factors are further refined.

(4) Finally determine the KPI evaluation system in the view of organizational structure.

4.2. KPI Design of Production Cost

For the digital workshop, the production system can create value for it, and the production cost will have a direct impact on the profit and competitiveness of the digital workshop. According to the above design idea, according to the different objects required for production, the value tree logic tool is used to decompose them, and the production cost is divided into labor cost, equipment cost, energy cost, material cost and time cost. See Figure 1 for details.

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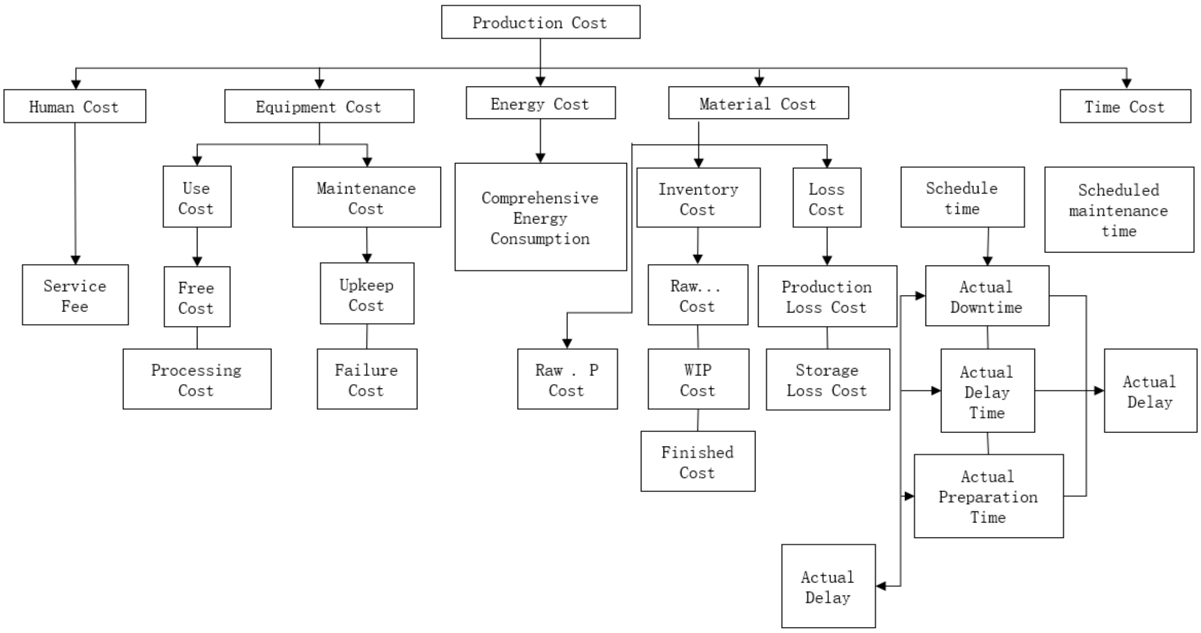

Figure 1. Cost factor value tree decomposition

4.3. KPI Design for Quality

Factory-level quality KPIs can be decomposed according to the manufacturing process, which can be divided into design process and manufacturing process. Product quality problems in digital workshop mainly occur in improper operation of products in the manufacturing process. Therefore, here we only study the quality problems occurring in the manufacturing process, generally have the quality of the materials required for manufacturing, improper operation in manufacturing and quality inspection of the quality problems. The value tree decomposition of quality factors is shown in Figure 2.

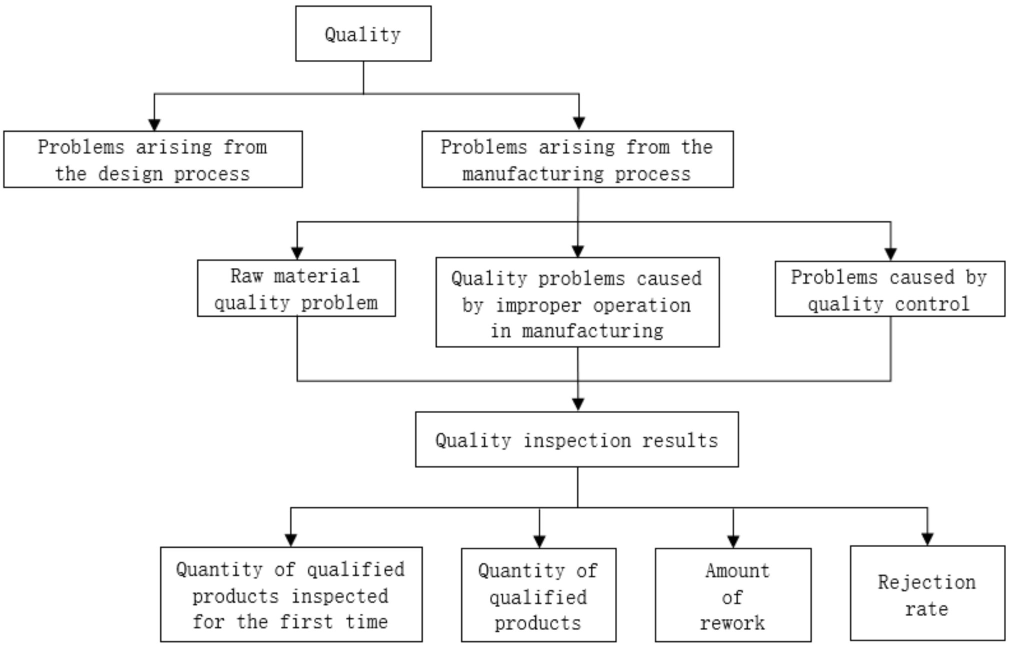

Figure 2. Quality factor value tree decomposition

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4.4. KPI Design for Delivery Time

Just-in-time delivery means the delivery of products that meet the requirements within the planned time. Therefore, the main factors affecting the delivery date are the specified delivery date and the production time to complete the order. Production time to complete orders mainly refers to actual production time, preparation time, delay time, downtime and buffer time. The decomposition of value tree of the factors of delivery time is shown in Figure 3.

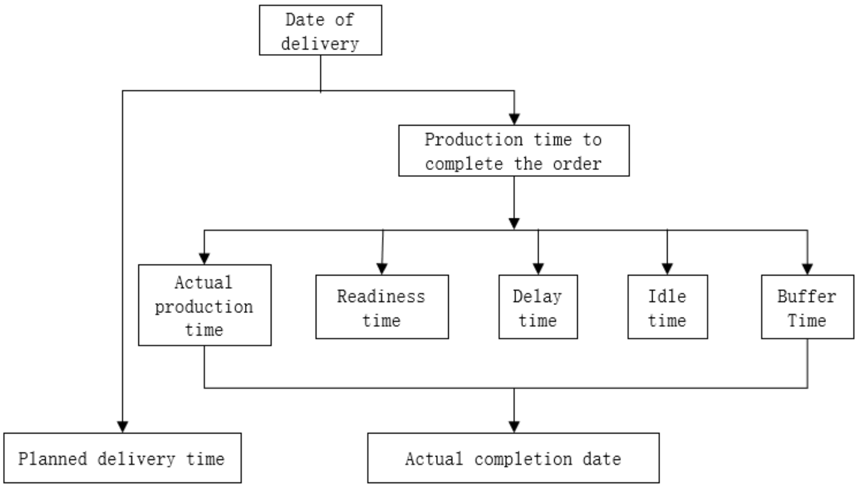

Figure 3. Delivery time factor value tree decomposition

To sum up, according to the key success factor method and value tree method, the digital workshop KPI evaluation system based on the organizational structure view is determined. In the organizational structure under the view of KPI evaluation system, the cost, quality, delivery date the three plant level KPI are subdivided into different scales of KPI, are employees work efficiency, equipment efficiency, energy consumption, inventory turns, quality index, on time delivery rate of 23 set KPI, the description of the specific KPI model see ISO22400 [7].

4.5. Common KPI Evaluation Methods

There are many methods to evaluate key performance indicators, and weighting each index is a common method. Scholars such as Zhang L Q [8], Wen-Yong L I [9], and Kim [10] have adopted this method to evaluate KPI. This method is suitable for quantitative, linear KPIS evaluation with relatively simple data structure.

For a large number of nonlinear KPIs, it is difficult to determine their computational process or analytical structure, because the neural network can high-speed parallel processing data, can solve the calculation and prediction of nonlinear system, can carry out fast calculation and summary, most of the time are used to process the neural network. Li Y [11] established the KPI comprehensive evaluation model of coal enterprises by using BP neural network. By calling the trained model, comprehensive evaluation can be carried out on enterprises. Mingang [12] designed the KPI evaluation system of emergency logistics based on the factors affecting emergency logistics, and constructed the KPI evaluation model by using BP neural network. Finally, the effectiveness of the model was verified through a case study. Lin L H [13] et al. used BP neural network to construct the supply chain KPI evaluation model, providing a new idea for the implementation of supply chain dynamic analysis. In view of the comprehensive consideration of the characteristics of KPI evaluation system structure, KPI characteristics and evaluation methods established in this paper, BP neural network, which is relatively mature and widely used in the neural network, can be selected here to build the KPI evaluation model of the digital workshop.

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5. Conclusion

Intelligent manufacturing is the main direction of the transformation and upgrading of China's manufacturing industry. As the core unit of intelligent manufacturing, the digital workshop is crucial to realize the global, real-time, transparent and dynamic management of the digital workshop. Based on Computer Integrated Manufacturing System (CIMS), an integrated management and control mode of digital workshop is established in this paper. Based on ISO22400 -- KPI series of manufacturing operation management standards, starting from the organizational structure view of the digital workshop, the KPI evaluation system of the digital workshop was established to support the integrated control system of the digital workshop by using tools such as key success factor method and value tree. The establishment of the integrated control and evaluation model can help optimize the operation process of the entire production system, make the system more flexible, make the production process more automatic and efficient, and thus improve the production efficiency.

Acknowledgments

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