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Collection and Storage of Assembly Quality Data of Complex Electromechanical Products

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Abstract. In the context of made in China 2025 and intelligent manufacturing, “data-based decision” is one of the important concepts for quality management promotion, and data integrity and availability is an important aspect of data collection and data management. Combined with the characteristics of complex electromechanical products with complex structure, multiple development links and high quality requirements, this paper discusses the management category of quality big data from the perspective of manufacturing process operation management and product life cycle, studies the acquisition strategy by manual and automatic methods, acquisition process, the quality data modeling and expression specifications based on unified coding specifications and business flow and data flow framework and provides references for enterprises to carry out quality big data construction.

1. Introduction

In the context of made in China 2025 and intelligent manufacturing, digitization has become the basic work to which every enterprise pays more and more attention. In the fields of quality management, six sigma and continuous improvement, the “data-based decision” is one of the important concepts to promote [1]. Because of that, at present, a great number of studies have been carried out in the lean quality management in various fields and obtained certain achievements. On the basis of previous studies, combined with the complex structure, many development links and high quality requirements of the complex electromechanical products, this paper carries out the study on the collection and storage of multi-source heterogeneous quality data to provide data support for the enterprises to improve product quality, process quality and work quality.

The architecture of the main business of the manufacturing enterprise related to manufacturing is shown in Figure 1. Among them, production scheduling, production control, quality assurance, material and energy control, product inventory management and equipment maintenance management are the main businesses of manufacturing process operation management, while order management, cost accounting, procurement, R&D and marketing and other non-main businesses have an inseparable relationship with the manufacturing process [2].



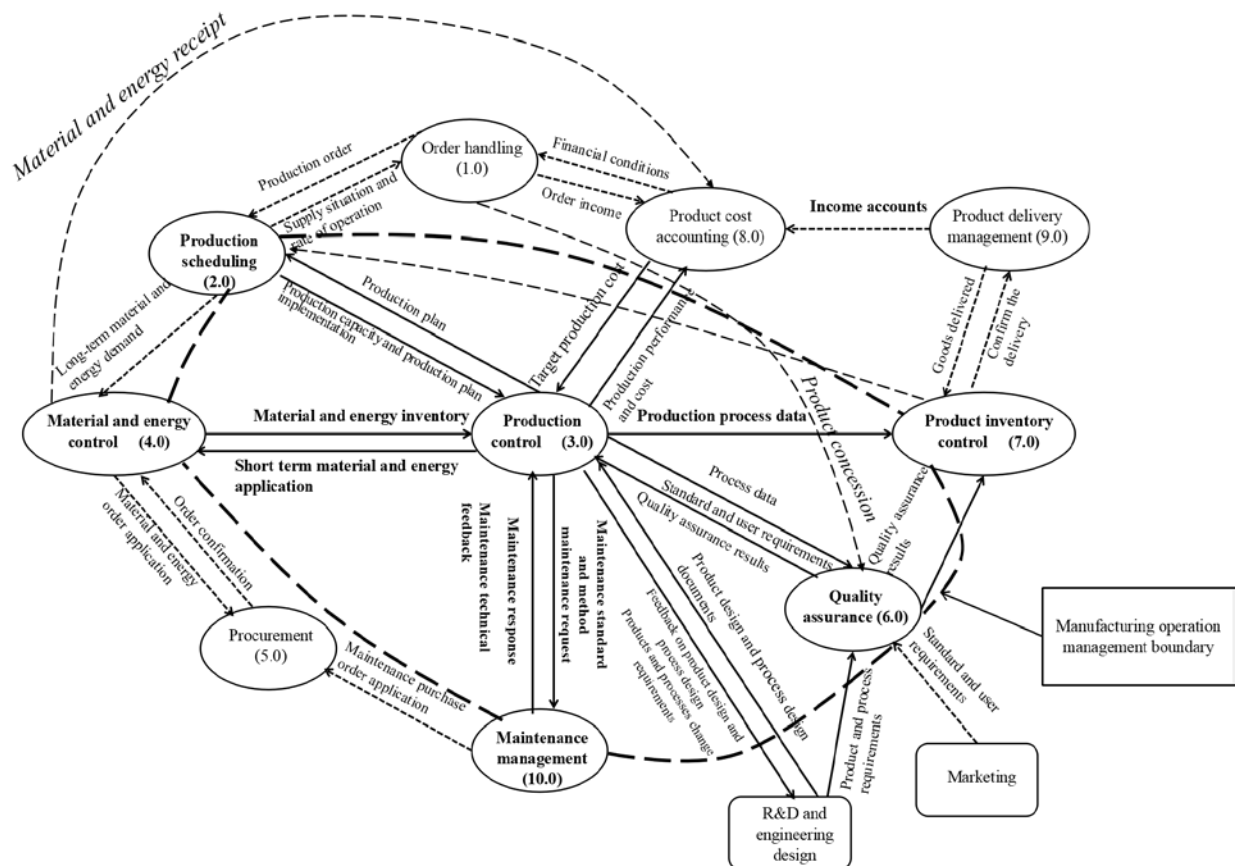


Figure 1. Manufacturing enterprise control function model

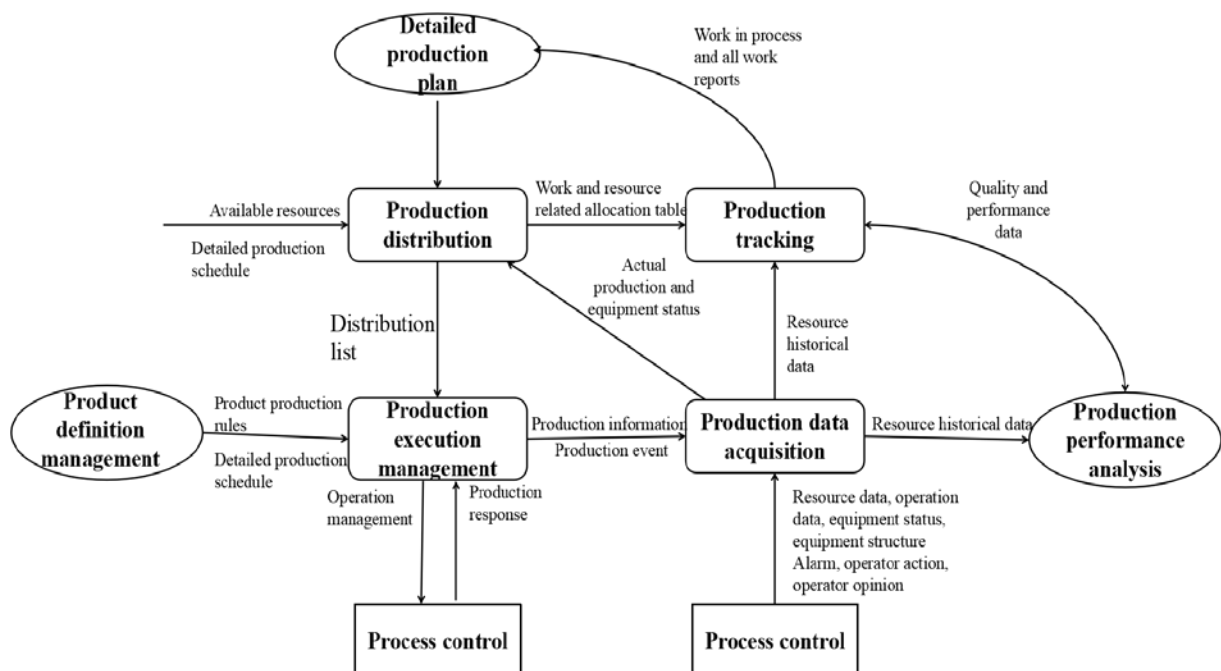


Figure 2. Correlation between various activities in the Process of Production Control

The activity of "production control" is to control the production, processing, assembly, debugging and other activities according to the production plan, that is, to monitor the man, machine, material, method, measurement and environment (5M1E) [3]. The fluctuation of 5M1E in the production process centrally reflects the implementation of the production plan [4]. On the one hand, the resource data, operation data, equipment status, quality problems and other information collected through production data collection activities can be used for production performance analysis. On the other hand, the documentary of production process can be used for production process tracking and is the basis of process capability evaluation and adjustment. The correlation between the various activities in the process of production control is shown in Figure 2.

2. Management category of quality big data

In the narrow sense, the quality data refers to the data related to product quality, such as the measured value of key characteristics, percent defective, percent of pass and first pass yield [5]. In the broad sense, the quality data reflects the product quality, process quality and work quality, such as fluctuation of process parameters, equipment operation condition, quality cost loss, production batch, inventory, invalid operation time, production plan completion, process change, equipment downtime loss, supply quality fluctuation and material shortage time, which will become the study objects of enterprise lean quality management. Therefore, the management category of quality big data refers to the basic information, status information, result information and analysis and evaluation information covering various business activities in each stage of product formation. From the perspective of manufacturing process operation management, the information included in quality big data is shown in Figure 3:

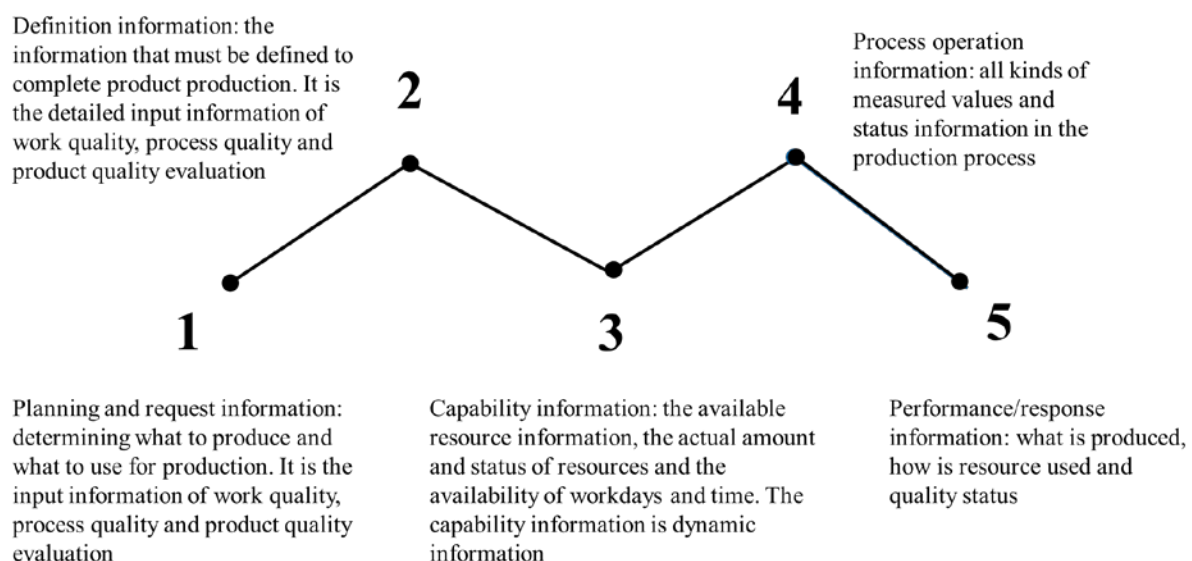


Figure 3. Information included in quality big data

The information in Figure 3 is both hierarchical and interrelated, and the correlation between the levels is shown in Figure 4. From the order placing, production plan preparation and plan execution to the collaborative operation of the 5M1E and other resources and production factors in the processes as well as the operation process and results, the organic whole shall be driven by the top-down production orders and plans on the one hand and achieves the short-term, medium-term and long-term analysis and evaluation of the whole manufacturing operation by perceiving the product, process, equipment and tool status and collecting the operating data on the other hand, so as to realize the closed loop control of the production process.

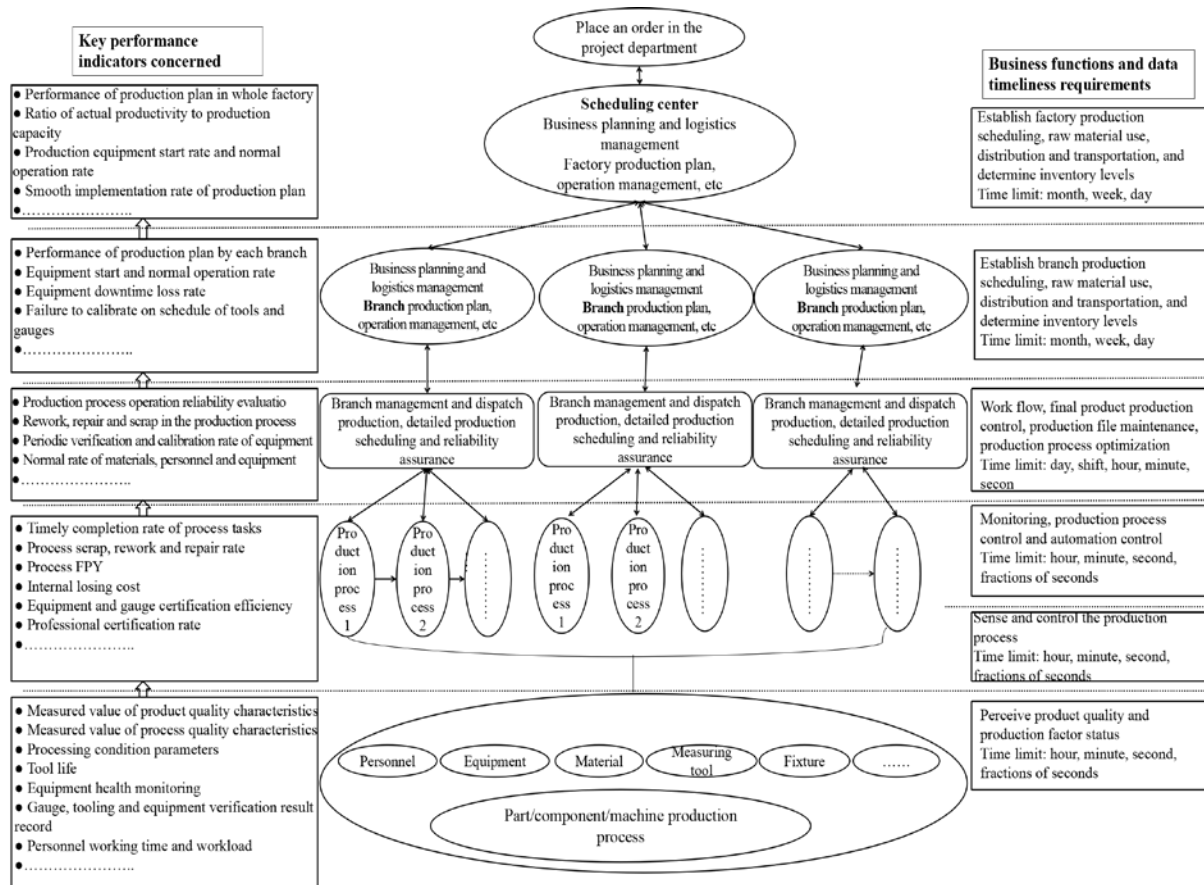


Figure 4. Hierarchical relationship between quality big data and manufacturing operation management process

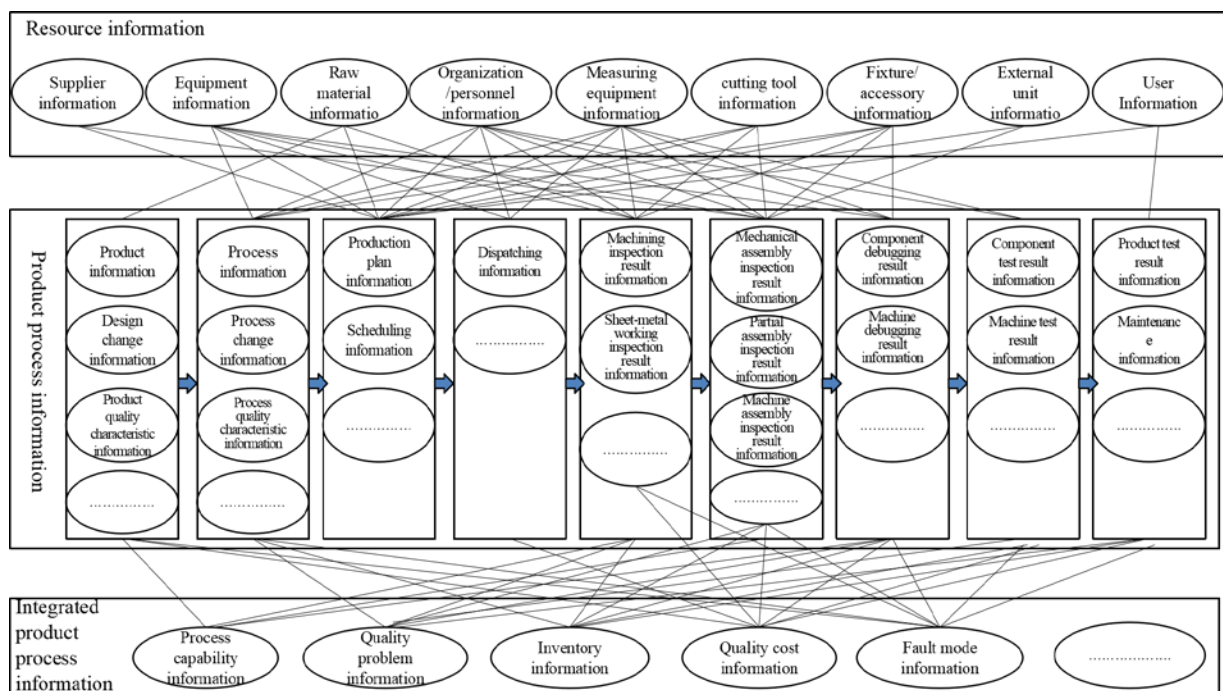


Figure 5. Composition and correlation of quality data

This paper analyzes the environment for the production of the quality data from the perspective of manufacturing process operation management above and analyzes how to evaluate the production plan, logistics, inventory and manufacturing process through quality data, as well as the correlation between quality data. At the same time, the quality data is formed at various stages of the product life cycle. Therefore, we need to analyze the management category of quality big data from the perspective of product life cycle.

Viewing quality big data from the perspective of product life cycle, the quality data can be classified into three categories: basic resource information, product process information and product process comprehensive information. The main composition and correlation of various types of information are shown in Figure 5.

The management category of quality big data includes the stage information of product formation process and the operation management information of each stage. It is a true multi-dimensional, multi-data type and strongly correlated data set.

3. Acquisition of quality big data

3.1. Purpose of acquisition of quality big data

The quality big data is acquired to effectively monitor and quantitatively assess the production operation, equipment maintenance operation, quality operation situation and inventory operation situation in the manufacturing process, then find out the bottleneck problems and optimize the manufacturing process, to achieve the purpose of gradually improving the manufacturing management system. From the perspective of product quality, process quality and work quality, the specific purpose of acquisition of the quality big data is shown in Figure 6:

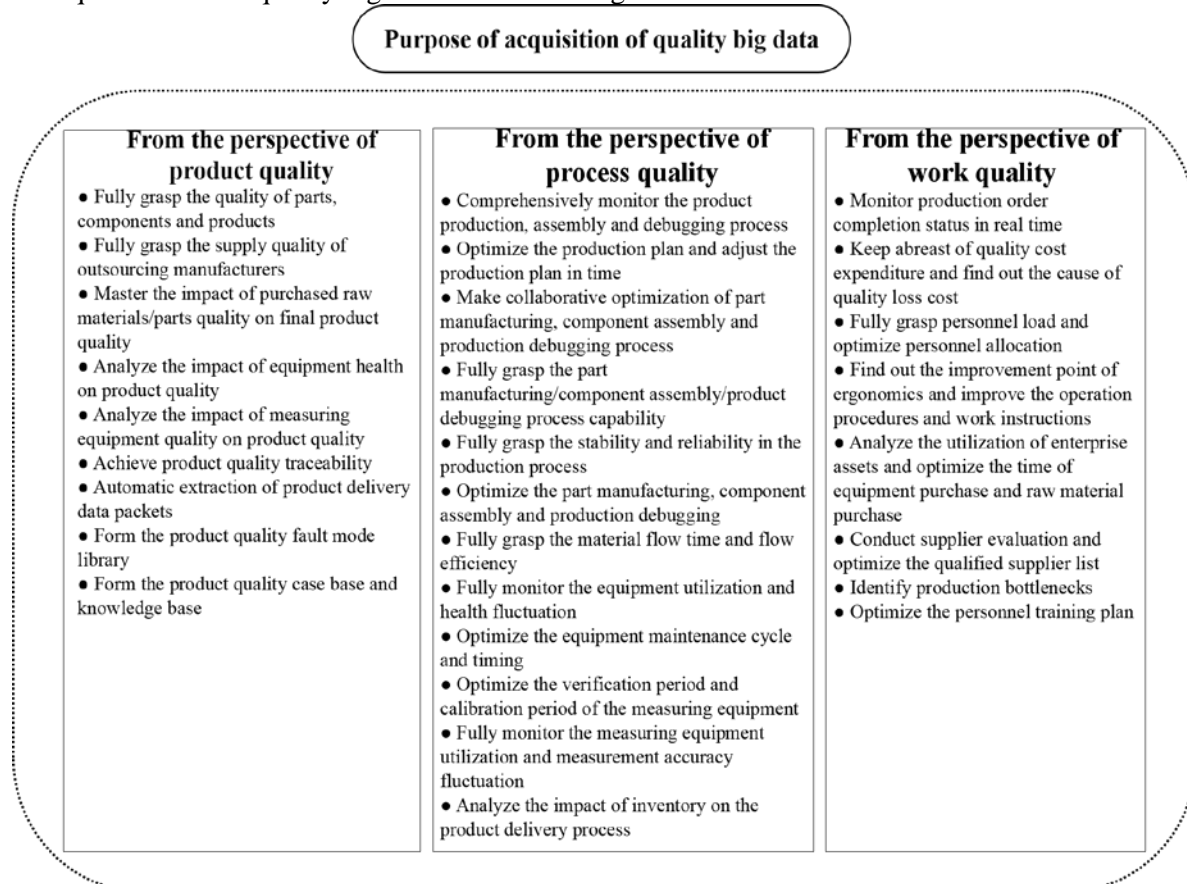


Figure 6. Purpose of acquisition of quality big data

3.2. Acquisition strategy of quality big data

Quality data includes data from process dimension, phase dimension and resource dimension and includes input information such as process and characteristic definitions and production plans, as well as output information of process execution results. Take the acquisition of quality data of a workshop production process as an example. Figure 7 is an example of the input data and output data of the manufacturing process.

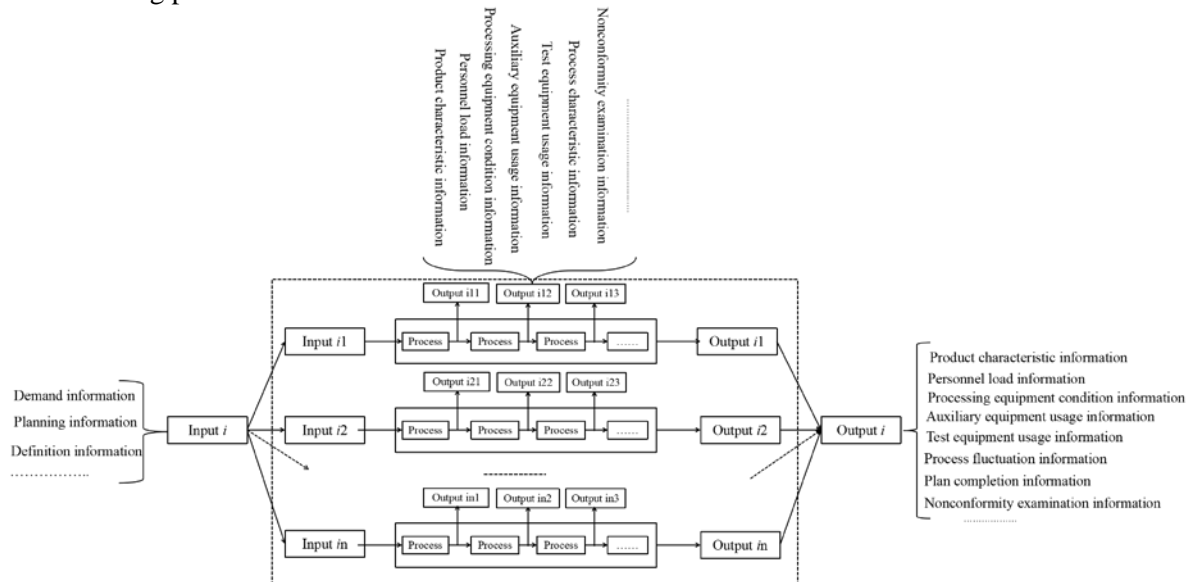


Figure 7. Sample of quality data acquisition during production

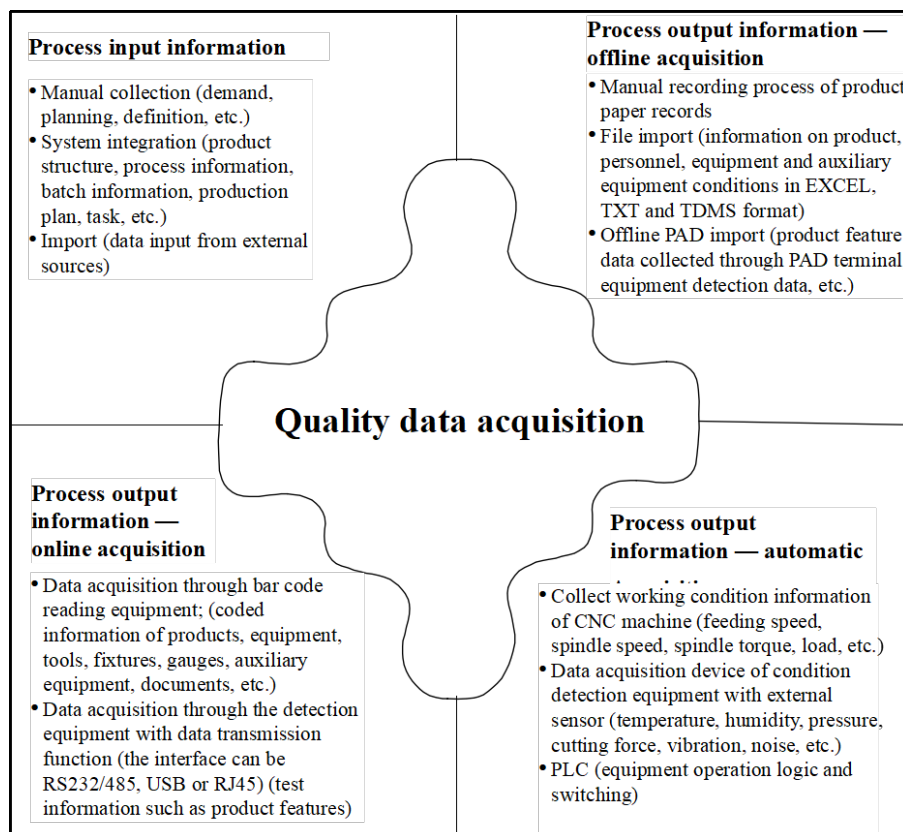


Figure 8. Quality data acquisition method

These data can be acquired both manually and automatically. The manual mode also includes discrete acquisition and online acquisition. Discrete manual quality data acquisition can be recorded by means of informatization of paper records, file import, offline PDA, etc. The manual online acquisition is to use the test equipment with data transmission function to realize the acquisition of test results data triggered manually. Automatic data acquisition is to automatically collect the working condition data of the production process through the data acquisition card in the specified sampling period by adding a sensor. The data acquisition method is shown in Figure 8.

3.3. Acquisition process of quality big data

The quality data is collected and integrated according to the logical level of unit - workshop - enterprise. The acquisition process is shown in Figure 9.

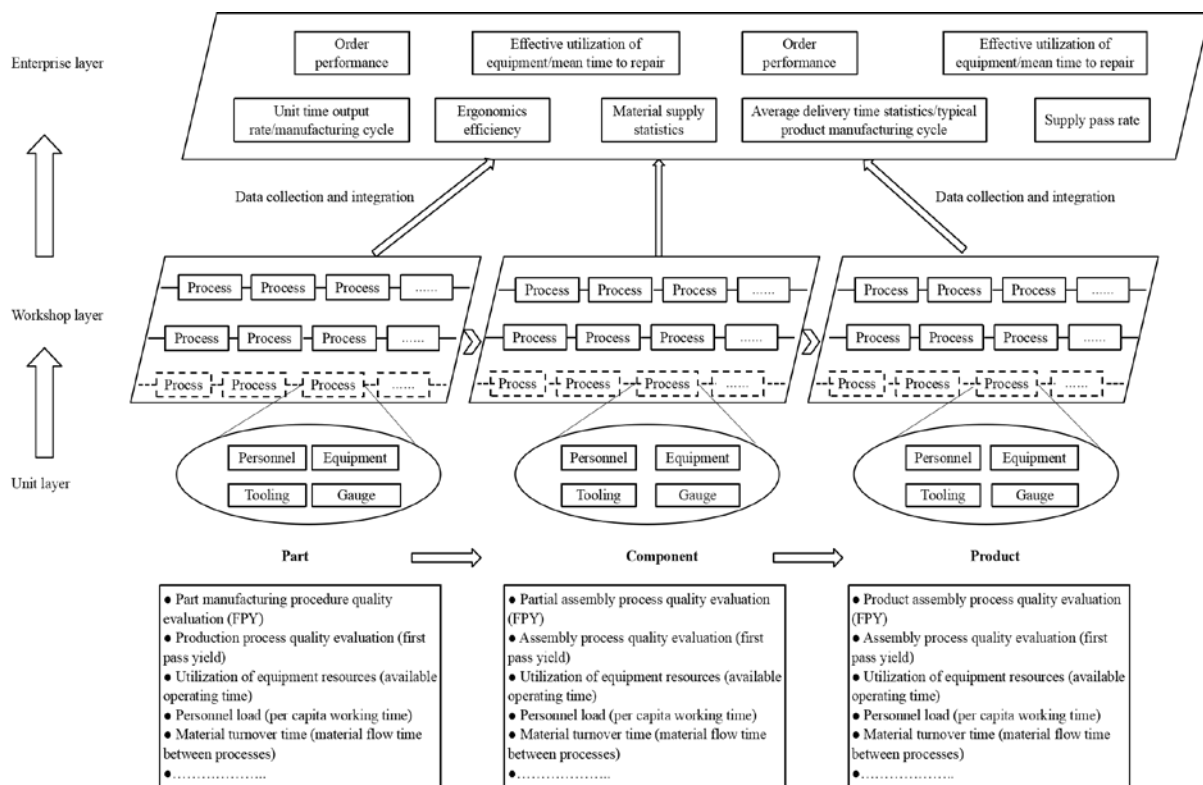


Figure 9. Flowchart of quality big data acquisition

4. Storage specification of quality big data

4.1. Based on unified coding specification

For storage and analysis of quality data, the quality data shall be stored based on unified basic resource coding and material coding.

For the basic resource coding, full consideration shall be taken into the management requirements of classification, stratification and uniqueness, and the compilation of unified basic coding for enterprise resource sharing. The management basis is provided for realizing unified standard management of basic resources, monitoring of resource status, uniform optimized allocation of resources, and forecasting of resource purchase quantity and time. Basic resources include: equipment, tools, measuring tools, fixtures, auxiliary equipment and personnel. The unified coding of basic resources is the basis and key to realize the quality management of production site based on Internet of Things.

The material coding shall take full account of the requirements for classification and stratification in management and for the correlation with the processing of products and parts in the production process, and is the basis and key to achieve the traceability of materials for products and production processes.

4.2. Based on business flow and data flow framework

The storage of quality big data shall match the actual business flow, and a detailed business flow and data flow framework shall be developed, as shown in Figure 10. The framework implements a top-down demand planning, task decomposition, manufacturing execution and field control and bottom-up information feedback and achieves the quality analysis and evaluation of the products, equipment, materials, personnel, production plan, manufacturing process and supplier through input and output analysis and comparison of each unit and process.

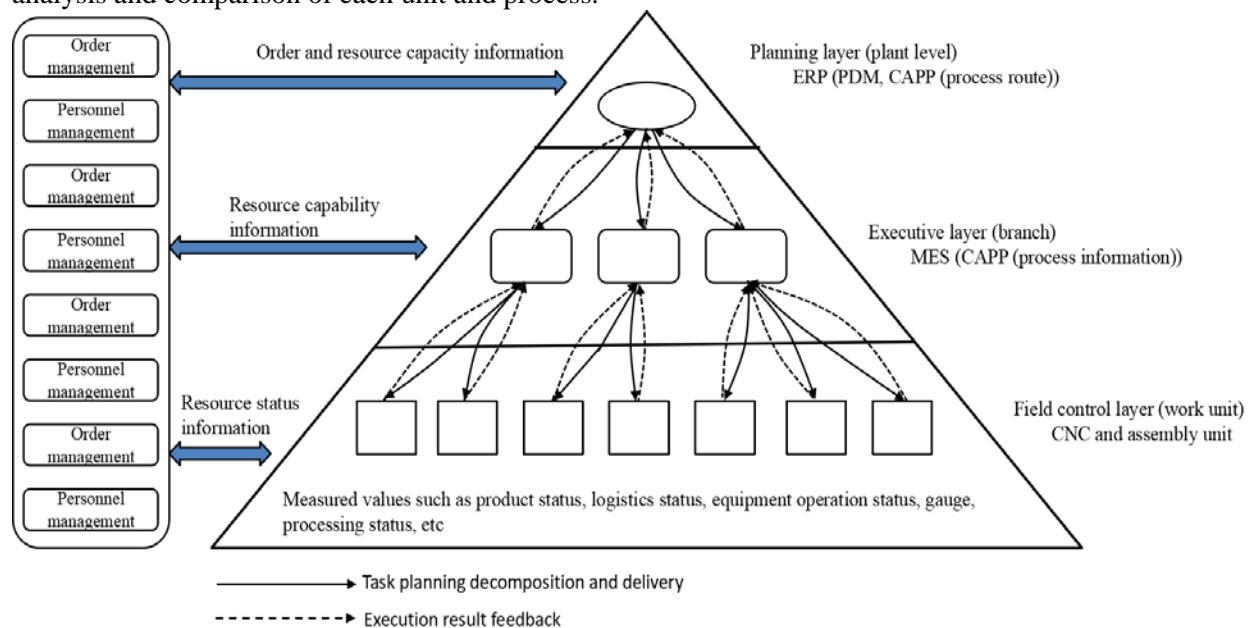


Figure 10. Business flow and data flow framework of quality big data management system

4.3. Quality data modeling and expression specification

All quality data are output of inspection or measurement activities, which are generated in a certain situation. Only the quality data with detailed situation information can be used for the quality problem tracing and the statistics and analysis of process, production process, batch and product. At the same time, the optimization of production process, of personnel workload and of production task can be realized by calculating operation time, process waiting time and inspection time through the start time and completion time of each process. It can be seen that the situation information of quality data is the basis for quality data classification, automatic collection, quality data based statistical analysis and process optimization. Therefore, it is necessary to establish the expression specification of quality data. The organization model and components of the quality data are shown in Figure 11.

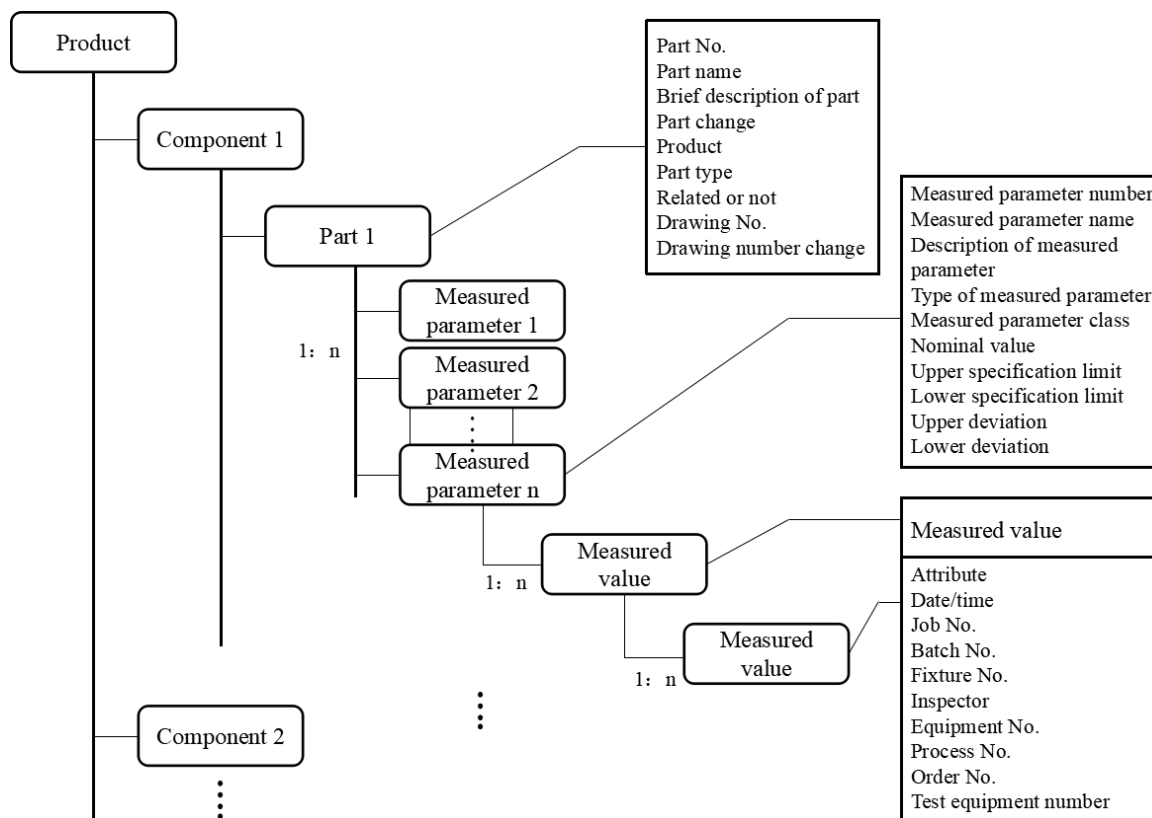


Figure 11. Organization model and components of quality data

5. Conclusion

Data integrity and availability is an important aspect of data acquisition and data management. Only corresponding to the product, parameter name, measurement time, surveyor and the product production equipment correctly, a quality data can truly play the value, provide material available for data analysis in the future and provide data support for enterprises to improve product quality, process quality and work quality.

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