Research on Formation Analysis and Fusion Processing Method of Multi-source Quality Data

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Abstract. In view of the lack of unified, standardized description methods and heterogeneous quality data fusion processing methods for multi-source quality data in the quality control process of the manufacturing process. This paper analyzes the data source, formation process and data interface of multi-source quality data in the manufacturing process, builds a quality information model for manufacturing process quality control, uses failure mode analysis and optimization to identify key quality characteristics of product manufacturing process, collects and fuses the multi-source heterogeneous quality data produced in multi-variety mass production, and provides reliable and reusable data resources for manufacturing process quality analysis control and batch quality evaluation.

1. Preface

Product quality control is the basis for the survival and development of manufacturing enterprises. The product manufacturing process is the main link in the formation of product quality and the key to achieving product quality. In view of this, this article conducts a detailed investigation and analysis of the quality information of the manufacturing process. According to the 5M1E that affects product quality, namely, human, machine, material, method, environment, measurement (Man, Machine, Material, Method, Measurement, Environment) and product for the quality characteristics in the manufacturing process, the identification of key quality characteristics of products based on failure mode analysis is proposed, and multi-source quality data is fused to maximize the value of quality.
information. Therefore, this method has important theoretical research value and Application value of enterprise quality management.

2. Multi-source quality data formation analysis and modeling
Building a data model of data collection, management and mining can provide the most valuable basic information support for the in-depth analysis and quality control of quality data, give full play to the advantages of digital system, build an efficient data analysis platform, and truly realize the quality control. According to the different manifestations of quality information at different stages of the product manufacturing process, analyze the data sources, formation process, data expression methods and interfaces of multi-source quality data in the manufacturing process, and construct the product manufacturing quality information model as shown in Figure 1. Product manufacturing quality information model includes manufacturing industrial design data, testing process data, production site inspection data, quality improvement data, key quality characteristic data, unqualified product statistics, experimental data, quality accident analysis and processing report, etc. The quality information model is shown in Figure 1.

![Figure 1. Quality information model.](image)

This article uses standardized and standardized description methods to uniformly describe the manufacturing quality information. The description of the manufacturing information model is as follows:

(1) Construction of quality information model tree: Based on the structure of the product, according to the quality control requirements of the product, standardize the quality information composition and quality data expression, and build a unified quality information model tree;

(2) Quality data collection and acquisition: At present, China's equipment manufacturing industry is in the automated/semi-automated stage. The digital collection methods mainly include data collection methods such as radio frequency identification technology (RFID) and barcode recognition technology; and various advanced assembly Measurement equipment such as laser tracker, lidar, three-dimensional coordinate measuring instrument, indoor iGPS measurement, articulated arm measurement and other digital measurement instruments and equipment; at the same time, it also
includes the conversion and import of data from various digital application systems, such as CAD, DELMIA, 3DVIA Composer, Data information generated by ERP, MES and other application systems.

Product manufacturing quality electronic resume formation: through the barcode scanning of the product production process, the identification information of the parts to be tested is identified, and then the manufacturing quality data of the process is collected, processed and stored online to realize the identification of parts and quality information One-to-one correspondence. When all the processes are processed, an electronic product manufacturing quality resume will be formed, including product batches, material numbers, assembly personnel, inspection personnel, processing and assembly process process parameters, quality inspection data and other information to achieve quality problems Two-way traceability and analysis, when defects are found in the debugging process or after-sales, the barcode information can be quickly traced back to the quality information of the entire production process. Figure 2 shows the organization of product manufacturing quality electronic resume data.

![Figure 2. Electronic resume of product manufacturing quality.](image)

The electronic history of product manufacturing quality mainly contains the following information: (1) Production number: a unique identifier for tracing product quality information; (2) Bill of materials: used to record all key material information in the product production process, and the material information is identified by barcode (3) Production process quality information: used to record the quality data of all self-made parts of the product from the rough, processing, assembly to the final delivery of the production process, and store it in the quality database as structured data; (4) leave the factory Test quality data: used to record the inspection data of the product factory test.

3. Identification of key quality characteristics of products based on failure mode analysis

Failure Mode and Effects Analysis (FMEA) is a tool for evaluating potential failure modes and their causes in advanced quality planning. Begin by analyzing a detailed list of all components in the system, and analyze the entire system one component at a time. The system can be hierarchically divided into subsystems, and FMEA can be performed on each group in the hierarchical structure according to the analysis objective. FMEA can be very effective in identifying potential serious failures in equipment, so that the design can be changed to eliminate serious failures. For this reason, the best time for FMEA is in the design phase of the project. FMEA should make design changes without changing the entire project. Ideally, the completed FMEA will find no serious failures.
Equipment manufacturing products will produce a large amount of process information and data during the manufacturing process. These data involve personnel, equipment, parts, inspection, quality, technology, manufacturing and management. In the manufacturing process, two complete quality It is impossible to achieve the same product, and there will always be more or less differences in the quality of each manufacturing. This inherent quality of quality is called the volatility of quality variation, which is also called variability. The causes of quality variation in the production process are usually the five major factors of "human, machine, material, method, and environment", and the influence of each factor is shown in Table 1. In this paper, the identification method of product critical quality characteristics based on failure mode analysis is used to establish the product failure analysis decision tree to analyze the quality influencing factors of product manufacturing process and the quality control bottleneck of key manufacturing process, and quantify the failure factors through the level analysis of product design quality requirements and historical product quality data. The key quality characteristics in the manufacturing process are identified, and the key quality characteristics are transformed into the key quality control points in the manufacturing process to carry out the quality control of the whole process. The identification of product critical quality characteristics based on failure mode analysis is shown in Figure 3.

Table 1. Influencing factors of quality variation

| Factor       | Influence content                                      |
|--------------|-------------------------------------------------------|
| Personnel    | Personnel’s educational level, technical level, physical health, and psychological quality |
| Equipment    | Equipment service life, operating status, maintenance status, failure frequency |
| Materials    | Manufacturing accuracy, material, dimensions          |
| Method       | Assembly process plan, inspection process plan         |
| Environment  | Humidity, lighting, air pressure, noise, vibration     |

The steps of identifying the key quality characteristics of products based on failure mode analysis are as follows:

1) Failure tree analysis of failure factors: through the analysis of product functions, structural characteristics and principle of action, check product drawings, manufacturing and acceptance technical conditions, process regulations and processing characteristics, collect the series of products in scientific research, production, storage, and use. The failure phenomena that have occurred in the process and the quality problems that have occurred in similar products, while drawing on and referring to relevant analysis materials, according to the product from the factory to the final use, divide the failure modes of each stage, and analyze the nature of the failure modes to construct Out the failure tree of the product.
(2) The analytic hierarchy process selection of important failure factors: based on the degree of influence of failure factors on product failure and the probability of occurrence of failure factors as the selection principle, establish the hierarchical structure of the selection of important factors and their weights, organize an expert group to score the failure factors, Use the analytic hierarchy process to analyze the failure factor score value, and sort the failure factors according to comprehensive ranking, safety, reliability, storage, compatibility, personnel, equipment, materials, technology, environment, testing, etc. Sort, select and identify the key quality characteristics in the product manufacturing process.

4. Multi-source quality data collection and fusion processing for multi-variety mass production
Set key quality data inspection points in the manufacturing process for key quality characteristics, and use digital inspection technology to realize the collection of quality data such as key locations, key quality requirements, and product performance parameters in the product manufacturing process. By studying the fusion processing methods of multi-source quality data such as data cleaning with multi-level combination and optimization of filtering rules, integrated modeling of multi-source heterogeneous quality data, and construction of multi-source heterogeneous quality data multi-dimensional views, the quality inspection data and historical quality data are processed Data conversion and mapping, as well as the collaborative processing of multiple quality characteristic parameters, are transformed into quality data in a unified format, providing data resources for data-driven quality integrated management and control. Figure 4 shows the multi-source heterogeneous quality data fusion processing method.

5. Conclusion
Aiming at the problem of large amount of information and lack of unified, standardized description method and heterogeneous quality data fusion processing method in the process of digital manufacturing quality control, this paper proposes a multi-source quality data formation analysis and fusion processing method. This method is simple and practical, and has high universality. It can
provide reliable and reusable data resources for quality analysis, control and quality evaluation in the
manufacturing process, realize the product quality management in the manufacturing process, and
effectively ensure the realization of enterprise quality objectives.

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