Design and Implementation of Quality Management System for Equipment Manufacturing Enterprises

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Abstract. In the tide of digital transformation, equipment manufacturing enterprises used cloud computing, big data, internet of things and other new generation information technologies to open up the information flow inside the enterprise and upstream and downstream enterprises in the supply chain. As an invisible attribute throughout the whole life cycle of products, quality was an important factor that affecting the combat effectiveness of equipment. Once quality problems occured, the equipment would fail in the battlefield, resulting in inestimable consequences. Due to the quality elements in each stage of equipment development existed in different forms, and the coarse granularity, collection means and measurement means were different, higher requirements were put forward for the tracking, tracing and control of product quality. Based on the quality control requirements and information construction foundation, this paper built a quality management system with product BOM as the core, which improving the traceability and visualization of quality information in the equipment development and production process, and accumulating data basis for intelligent quality analysis and decision-making in the future.

Key words: manufacturing enterprises; quality management; BOM; full life cycle; system design

1 INTRODUCTION

Equipment quality was the key factor that affected the combat effectiveness and victory of the army. Under the new situation and new requirements, tb he development mode of equipment had changed from "quantity" to "quality", and put forward higher requirements for equipment quality that quality management of the whole system and the whole life cycle [1-2]. With the development and application of information technology, quality management means had evolved to informatization and intelligence, which could provide more methods and ways to shorten the development cycle and continuously improve equipment efficiency [3-4].

In order to ensure the reliability and stable operation of products, the enterprise had formulated corresponding rules and regulations in combination with industry standards, and put forward clear quality management requirements at all stages of sales, design, production, delivery, after-sales and so on. However, due to the production characteristics of uncertain project cycle, frequent changes in user requirements, and the intersection and parallelism of design and manufacturing in the actual process, it was difficult to track the quality information. Once problem occurred, technicians needed to locate the cause of the fault from a pile of cards or records. At present, aerospace industry had done a lot of exploration and research in quality

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traceability informatization, mainly in the aspects of production and manufacturing process quality management, nonconforming product management, quality system and so on [5-10], while there was less research on equipment development cycle quality traceability with product BOM as the core.

According to the quality management requirements and the basis of enterprise informatization, this paper constructed a quality information management system from the perspective of product BOM, which could realize the standardization and visual management of quality data.

2 BUSINESS DEMAND ANALYSIS

The purpose of quality control was to control the key factors in each link of the equipment manufacturing process through certain control standards and control schemes, which could ensure that the equipment delivered to users meets the quality requirements. Generally, the equipment manufacturing process was divided into six stages: planning, design and development, procurement and sorting, production and manufacturing, commissioning and inspection and delivery. The quality control requirements and quality control objectives of each stage were different. Therefore, the collection methods of quality information were also different. For example, in the product planning stage, the quality assurance program defined the quality activities and quality control requirements of each stage, and the quality information existed in the form of documents. In the manufacturing stage, product quality was affected by factors such as process, worker proficiency, inspector inspection level, etc, and quality information existed in the form of drawings, documents or data. The quality elements at different stages of equipment manufacturing were shown in the figure 1.

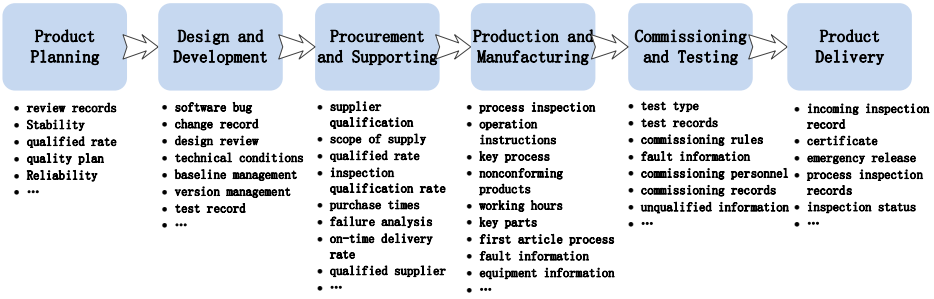

Figure 1.quality elements in different development stages

3 SYSTEM DESIGN AND IMPLEMENTATION

3.1 System architecture design

The quality management system based on product BOM was mainly divided into infrastructure layer, support layer, business layer and decision-making layer. Its architecture was shown in the figure 2. The quality management system was deeply integrated with other information systems within the enterprise, such as TDM, ERP, PLM, MES, etc. So as to realize the consistency of quality traceability in the manufacturing process. The main

integration interfaces were as follows:(1)PLM: Drawing document version, BOM, design change notice, stage identification,etc.(2)TDM: Component screening test, reliability test, environmental test ,etc.(3)PMS: Arrival inspection application, arrival inspection record, delivery on time rate ,etc.(4)SRM: Supplier qualification, list of qualified suppliers, scope of supply,etc.(5)MES:Process level inspection, process, assembly list, nonconforming product application,etc.

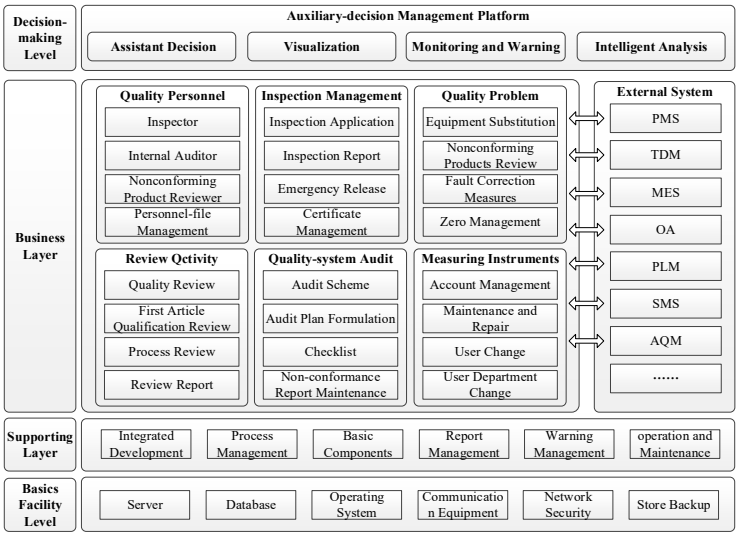

Figure 2. Quality management system architecture based on product BOM

3.2 system function overview

The quality management system of equipment manufacturing enterprises mainly included six modules: quality personnel management, product inspection management, quality problem management, quality review activity management, quality system audit management and measuring devices management. This section mainly described the detailed design of each module.

(1) Quality personnel management was mainly used to manage the qualifications of inspectors, internal auditors and nonconforming product reviewers, including registration, renewal, etc.

(2) Inspection management realized the management of multiple types of inspection business in the process of equipment development, such as incoming inspection, warehousing inspection, pre-test status inspection and so on.

(3) Quality problem management realized the collection and management of quality problems found in the whole life cycle. According to the timing of discovery and the severity of the problem, it was divided into equipment substitution, nonconforming product review, fault correction measures, etc.

(4) Quality review activities management realized the management of relevant product quality review activities in the stage of development and before small batch production,

mainly including product quality review, first article identification review and process review.

(5) Quality system audit management supervised the whole process of product development, and recorded the problems and nonconformities found in the audit process, which refering to the requirements of internal procedure documents, quality plan and other documents.

(6) Measuring instruments management realized the management of measuring devices from procurement to scrapping, mainly including the function of purchase, acceptance, verification, maintenance, user change, etc.

4 KEY TECHNOLOGY RESEARCH

4.1 Quality information traceability technology based on product BOM

According to usage, BOM can be divided into design BOM, process bom, maintenance BOM, manufacturing BOM, etc. Most equipment belongs to the category of complex systems. Therefore, product BOM has the characteristics of multiple levels and complex structure composition. Once quality problems occur, it was necessary to trace the quality of all links of development. Figure 3 showed that with the product BOM as the main line, and the quality elements of each stage of production and manufacturing as basic, the quality information traceability technology based on the product BOM realized the design and collection of key quality attributes of different types and levels of materials, and constructed the product quality resume, which continuously improving the quality control level and quality traceability ability in the development process. There were three management attributes of self-made parts, purchased parts and outsourced parts in the product BOM. Generally, the serial number was used as the unique identification in each production department. However, for some purchased parts that were small and difficult to manage individually, batch management was adopted.

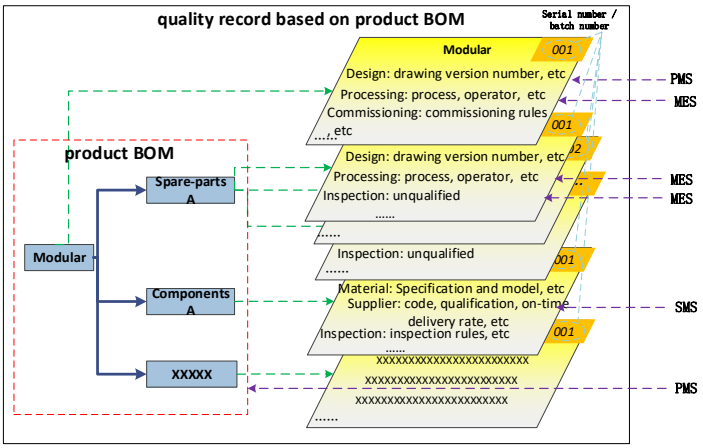

Figure 3. Quality record based on product BOM

4.2 Quality tree construction technology in product development process

As shown in Figure 4, the quality tree construction technology of product development process realized the deep integration of quality control and product development process. Firstly, the technical data such as the occurrence time, severity level and cause of quality problems were uniformly defined. Secondly, the control means such as design quality information transfer table, fault correction measures, quality zeroing, nonconforming product review were standardized. Finally, on the basis of information system integration, the quality problems found in the design, production, manufacturing, commissioning, inspection, testing and after-sales stages were located and tracked. The quality tree of equipment development process was constructed according to the collected quality information, which could provide data support for product quality evaluation, quality improvement and risk prevention and control. It was worth mentioning that the quality of the product development process was not only concerned with the product itself, but also the quality information of all levels of materials in the product BOM.

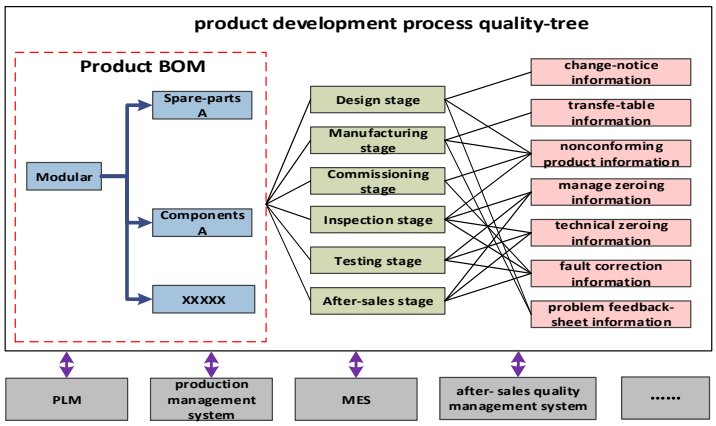

Figure 4. Product development process quality tree

5 APPLICATION EFFECT

5.1 Inspection management

Inspection management realized functions of inspection application and inspection record, which could support incoming inspection, factory inspection, pre-test inspection and other businesses. According to different inspection business types, two processing processes were designed: (1)After receiving the goods, the purchaser initiated an inspection application in the quality management system. The inspectors were responsible for screening tests, entering the inspection results in the TDM system and returning them to the quality management system. The warehouse keeper shall handle warehousing in the PMS according to the inspection results.(2) The inspector initiated an inspection requisition and maintained the inspection rules,which were from the PLM. Then the system would generate multiple inspection records according to the properties such as material name and serial number. The inspector recorded the inspection results in the system. At the same time, it could quickly generate the inspection

request of subordinate materials according to the material BOM information in the PMS. The inspection results of components were shown in the figure 5.

Inspection Application Number	Material name	specifications	Batch number	Applied quantity	Qualified quantity	Unqualified quantity	Inspection Request Date	Date received	Inspection completion date	Inspection cycle
JYSQ2204026015	Resistance	RM1608	RC2112124142	4000	4000	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2204026016	Resistance	C74	STC2202007701	4000	4000	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2204026016	Resistance	C741-0603-X7R	STC2202002601	1000	1000	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2204026016	Resistance	C741-0603-X5R	STC2202010101	500	500	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2204026016	Resistance	C741-0805	STC2202010201	500	500	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2204026016	Resistance	C741-0603-CG	STC2202007901	1000	1000	0	2022/4/2	2022/4/2	2022/4/2	1
JYSQ2202176006	Resistance	RMK2012KB102FP	2112024750	100	100	0	2022/2/17	2022/2/18	2022/2/18	2
JYSQ2203036009	Electromagnetic relay	2JL0.5-1	20011	90	90	0	2022/3/3	2022/3/9	2022/3/9	7
JYSQ2203016007	Connector	YMG22	22012005	20	20	0	2022/3/1	2022/3/9	2022/3/9	9
JYSQ2203016007	Connector	YMG16T7	22012001	20	20	0	2022/3/1	2022/3/9	2022/3/9	9
JYSQ2203016007	Connector	YMG120T7	22012010	50	50	0	2022/3/1	2022/3/9	2022/3/9	9

Figure 5. Component inspection results

5.2 Nonconforming product review management

"MES-push" was used to distinguish the management level of nonconforming product review process. When nonconforming products were found and been verified by the on-site inspector in the manufacturing process, the worker initiated the nonconforming product review at the station end and passed it to the process personnel. In the quality management system, the process personnel would judge the cause of the received nonconforming product review and gave the review conclusion. After the inspector's review, the review conclusion would be fed back to the MES station end to guide the workers' next operation. For nonconforming products found by the design department and the quality department in the commissioning, inspection, test, after-sales and other links, a nonconforming product review was created in the quality management system to describe the detailed characteristics of nonconforming products, and transmitted to the responsible department to find out the causes and rectify. When the problem was serious, the review conclusion would be decided by the members of the nonconforming product review team. Nonconforming products review process in the manufacturing department as showed in figure.6.

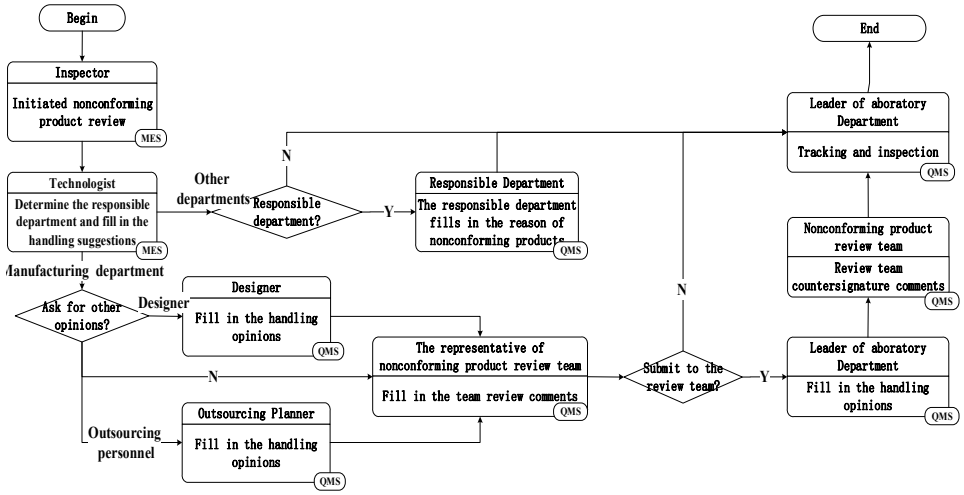

Figure 6. Nonconforming products review process in the manufacturing department

6 CONCLUSION

Based on the analysis of the quality control elements and the characteristics of the quality information carrier in the equipment development and production process, this paper designed a quality management system based on the product BOM. In this process, it focused on quality information traceability technology and quality tree construction technology. Through the collection, tracking, statistics and visual display of quality information in different stages and links, the enterprise's product quality control ability and product quality level were improved. Next, we would study the quality risk model and carry out quality prediction and risk prompt for activities in each stage.

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