Research on Integrated Quality Control in Product Manufacturing Stage

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Abstract. In view of the weak quality control in manufacturing process, the lack of data support in decision planning layer and management control layer, this paper analyzes the operation flow and quality data link of data-driven product manufacturing quality integrated control business operation process and quality data link, studies the multi-process manufacturing process quality integrated control method, realizes the machining error and quality dynamic control between multi-process in complex parts manufacturing process, improves the machining precision and efficiency of parts, puts forward the dynamic control method of machining process quality for component assembly, establishes the relationship between complex process capability index and matching degree, and realizes the prediction analysis and optimal matching of assembly results, effectively improve the assembly quality and assembly efficiency of precision components.

1 Introduction

With the gradual formation of the trend of economic globalization, the domestic manufacturing industry is facing the market competition of international advanced production technology and high-quality products. In order to gain advantages and initiative in the increasingly fierce competition, enterprises must cope with the increasing demand for products from the perspectives of efficiency, quality, cost performance, service and more scientific cost performance products. Product quality is the key to continuously develop the market and maximize the interests of enterprises.

Most of the production and manufacturing stages of assembly manufacturing products have the characteristics of complex product structure, many parts, fast upgrading of product models, complex manufacturing stage, high requirements on the control capability of production cycle, etc. Therefore, China's national defense and military enterprises need to shorten the production cycle and strengthen the quality and cost control, so as to be able to accurately respond to the national defense needs and implement the information quickly. A quality analysis and control method that can not only meet the needs of China's industrial development, but also effectively improve the production technology level and product quality of China's manufacturing enterprises is developed. At present, China has made some progress in quality control, but it still lacks the support of digital integrated control, which makes it difficult to give full play to the advantages of quality control in digital production lines. As a result, this paper studies the integrated control method of manufacturing stage quality focusing on the development trend of digitalization and
intelligence in the industrial field and the needs of enterprises, which strives to realize the real-time control of stage quality information.

2 Horizontal integrated control of manufacturing quality driven by data

By analyzing the manufacturing stage of parts and taking "quality data" as the core, a new business mode of horizontal integrated management and control of manufacturing quality is established, which covers two application scenarios of online collection of quality data, quality statistical analysis, quality index control quality integrated management and control and cross-workshop quality integrated management and control in the multistage manufacturing stage of parts and components within the workshop. Horizontal integrated control of manufacturing quality is shown in Figure 1.

Figure 1. Horizontal integrated quality control.

(1) Integrated control of multistage quality in the workshop:
① Online collection of quality data: In the stage of product manufacturing, digital inspection equipment is used to collect the quality information of numerical control machining equipment, automatic inspection equipment and machining parameters of parts working procedures in the bottom workshop on line. What’s more, through the industrial network, the quality information of the manufacturing stage is transmitted to the quality database in real time.

② Quality data analysis: According to the quality information collected by the input prior processing and combined with relevant historical data, statistical analysis is carried out on the data and control charts and histograms are drawn to comprehensively judge the processing quality of parts by data deformation.

③ Feedback and control of quality data: Through feedback of stage quality data in the manufacturing stage, production personnel make qualitative evaluation of stage capability and make prediction of the processing stage according to quality evaluation information.

(2) Cross-workshop quality integration control: This paper aims at ensuring the production quality of the downstream workshop and takes the lowest processing cost as the constraint condition to solve the quality of the upstream workshop, so as to realize the optimization of the quality information of the upstream workshop and the integrated quality control of the manufacturing stage across workshops.
Vertical integrated control of manufacturing quality driven by data

By analyzing the logical relationship between quality management and other business in manufacturing stage, the quality formation business stage in the manufacturing stage is integrated guided by business flow and data flow, the quality characteristic control and quality management stage are embedded into the digital manufacturing stage, and a vertical integrated control mechanism running through the whole stage of manufacturing quality information is established. Vertical integrated control of manufacturing quality is shown in Figure 2.

![Figure 2. Vertically integrated management and control.](image)

1. Workshop layer: It records the most detailed information on the production site. This layer is the basis for realizing vertical integrated control of manufacturing quality. Its main function is to use touch screen, bar code, sensor, handheld terminal collector, tablet computer and other technologies to ensure real-time, accurate, dynamic and reliable acquisition of multi-source manufacturing stage information based on component inspection stage documents and aiming at key quality characteristic dimensions.

2. Stage layer: This is the core layer of the quality control mode and serves as a link between the preceding and the following. Its main functions are: Through filtering the quality information collected from the bottom layer, the correct information is correctly staged and analyzed, and delivered to the correct place in real time; Statistics and analysis of quality inspection data, real-time evaluation or early warning according to the statistical results of quality characteristic values, and realization of stage quality prevention and control; According to historical data, quality diagnosis shall be carried out for the stages that present adverse trends or are prone to quality problems; Seek the key factors that affect the quality, and put forward improvement plans at the same time.

3. Management layer: Management layer is the highest of quality control mode. The quality information of enterprise decision-making level includes the formulation of quality objectives, the operation and review report of quality system, and the decision-making of major quality issues. Its main function is to integrate with other enterprise application systems (QMS, MES, etc.) through quality data monitoring, quality data analysis, quality evaluation, quality tracing and quality improvement, and make real-time adjustment to the operation of bottom-level equipment according to feedback information to realize dynamic management in the manufacturing execution stage by multi-source quality information collected in manufacturing site.
4 Horizontal integrated control of manufacturing quality driven by data

Stage is the basic processing unit for the change of product quality. Different stages have different specific manifestations of the influencing factors, and the degree of influence of various influencing factors on quality characteristics is also different. Multistage Manufacturing Stage (MMP) is defined as a complicated stage in which multiple stages are used to realize product manufacturing. This stage is discrete, random and dynamic. Therefore, it is necessary to take the stage as the foothold to study the influence of various factors on product quality in the manufacturing stage, which is not only convenient to do specific research on various influencing factors, but also convenient to quickly find out the causes of the problems when quality problems occur.

Aiming at the multistage manufacturing stage of key parts, an integrated quality control method for multistage manufacturing stage based on key quality characteristics is adopted. In addition to the correlation between stages, they also have the characteristics of transmission, mainly the stage of quality error transmission with stages. By analyzing the formation stage of key quality characteristics of machined parts, a quality error transfer model in multistage manufacturing stage is established by studying the correlation of quality characteristics between stage nodes. As shown in Figure 3, the quality characteristics formed by some stages have a direct impact on the quality characteristics of the next stage. The mass characteristic set Qk-1 has a direct influence on the mass characteristic set Qk. However, some stages have no direct influence on the quality of the next stage, but they will have a direct influence on the following stage. The quality characteristic set Qk has no direct influence on the quality characteristic set Qk+1 generated by the next stage, but it has a direct influence on the quality characteristic set Qi formed by stage i. Therefore, by studying the quality error relationship of multistage manufacturing stage and constructing the quality error transfer model of multistage manufacturing stage, it lays a technical foundation for analyzing the influence degree of quality status between stages on subsequent manufacturing quality characteristics.

![Figure 3. Quality error transfer model of multi-process manufacturing process.](image)

Clarify the final product quality characteristics of multistage manufacturing process, and analyze the relationship between each stage and the quality characteristics. Based on the state space model, the identification model of key quality characteristics in multistage manufacturing stage is constructed. A critical quality data detection point is set up in the machining stage. Using the quality data collected in real time on the production site, the key quality characteristics are analyzed, the change trend of each key quality characteristic is calculated, and the quality control state of the current stage node is given, which realizes the dynamic tracking and integrated control of the quality information of key parts on the stage flow. The integrated quality control method for multistage manufacturing stage based on key quality characteristics is shown in Figure 4.
5 Assembly-oriented quality control method for machining stage

Like the machining stage, there is a certain correlation between the previous and next stages in the assembly stage. The deviation of the quality characteristics of the parts formed in the previous stage will affect the quality of the assembled products in the next stage. Since the assembly stage is a stage of combining several parts, the influence of the previous stage on the quality of the next stage in the assembly stage is not only manifested in the influence of the deviation of the quality characteristics of parts formed in the previous stage on the quality characteristics of the next stage, but also in the influence of the matching relationship between parts formed in multiple related previous stages on the quality characteristics of the next stage.

Figure 4. Quality integrated control method of multi process manufacturing process based on key quality characteristics.

Figure 5. Assembly-oriented quality control method of machining stage.
The machining stage of complex parts is a multistage manufacturing stage, and the quality data can be regarded as normal distribution. Therefore, the percentage of two normally distributed complex parts to be assembled that can be successfully paired is called the matching degree (P). For assembly-oriented quality control method for machining stage, the relationship between CPK and P is established, the quantitative evaluation formula of assembly-oriented machining stage quality control is derived, and a mathematical expression is formed with the product assembly matching degree as the objective function, the machining stage capability index as the variable and the assembly constraint as the boundary condition. The machining stage capability and matching degree are calculated by collecting the quality data of the trial production stage of parts, so as to realize the prediction and analysis of the assembly results. The quality control method of assembly-oriented machining stage is shown in Figure 5.

6 Conclusion

Manufacturing stage quality control is a key measure to ensure product quality. The "13th Five-Year Plan" for intelligent manufacturing and "Made in China 2025" are also the core proposals for the implementation of total quality management, which put forward higher requirements for manufacturing stage quality control. Under the background of modernization and intelligence, the automation level of the manufacturing stage in the equipment manufacturing industry is increasing daily, and the complexity of the stage is also increasing. Therefore, it is of great significance to study advanced quality management methods and quality control technologies for the development of China's advanced manufacturing mode.

References