Analysis and Research on Error Compensation of NC Machining Data Based on Big Data Warehouse Hive

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Abstract: With the continuous development of machinery manufacturing industry, precision machining has gradually become the main trend of modern manufacturing industry. As a new generation of machine tools, CNC machine tools have been widely used in the mechanical manufacturing industry. At the same time, the rapid development of precision machining technology and the continuous improvement of machining accuracy of parts put forward higher requirements for the machining accuracy of CNC machine tools. The error compensation method has the characteristics of strong universality and low input cost, that is, it does not need to transform the machine tool on the premise of meeting the certain precision requirements of the machine tool, and it has incomparable economic benefits compared with the huge cost of error prevention of CNC machine tools. In this paper, an error compensation strategy of NC machining data based on big data warehouse Hive is proposed to improve the comprehensive performance of NC machining system.

1. Introduction

With the continuous development of machinery manufacturing industry, precision machining has gradually become the main trend of modern manufacturing industry, and the error compensation technology has developed rapidly [1]. The error compensation method has the characteristics of strong versatility and low investment cost, that is, it does not need to transform the machine tool on the premise of meeting the certain precision requirements of the machine tool, and compared with the huge cost of error prevention of CNC machine tools, it has incomparable economic benefits, and has become the main method to solve the problem of CNC machine tool precision at present [2-3]. The complicated structure and motion relationship of the machine tool and the complicated servo control system restrict the further improvement of its machining accuracy [4]. In addition, the wear of machine tool parts and the change of their relative positions during the use process also lead to the decline of the machining accuracy of machine tools, which can't be used for the machining of complex and precise parts, resulting in a serious waste of equipment resources [5]. The error compensation method is to offset the original error of the current problem by artificially creating new errors. The cost of error compensation is much lower than that of purchasing high-precision machine tools or improving the accuracy of the machine tools themselves [6]. The error prevention method is to try to reduce the possible error sources and eliminate them through design, manufacture and assembly.

The development of manufacturing industry is inseparable from the requirements of market for product quality, and precision measurement technology plays an important foundation and prerequisite in the development of machinery industry. The development trend of modern mechanical manufacturing technology is high efficiency, high precision, high precision, high quality, high integration and high intelligence [7]. Among them, precision and ultra-precision machining technology is also an important standard to measure the level of national machinery manufacturing, and plays a key role in improving the international competitiveness of the country. Some high-precision equipment can only be manufactured by high-precision processing equipment, such as optical equipment for medical use, aerospace engine manufacturing and some high-end brand car manufacturing [8]. Correspondingly, a lot of requirements are put forward for the

detection technology of its equipment precision [9]. Its advantages are low learning cost, and users can quickly realize simple MapReduce statistics through SQL-like statements. Even if users are not familiar with MapReduce programs, they can also query, summarize and analyze data through distributed cluster environment as long as they are familiar with SQL language. In this paper, an error compensation strategy of NC machining data based on big data warehouse Hive is proposed to improve the comprehensive performance of NC machining system.

2. Application of NC machining in machining technology

On-line inspection of CNC machine tools is based on the inspection of CNC machine tools, and its working environment is much worse than that of CMM, so the inspection accuracy is far less than that of CMM. In the traditional statistical theory, the distribution form of samples is known, and then the corresponding parameters are determined through a large number of data operations, so as to realize statistical modeling. However, usually, the distribution form of most samples is unknown, and the specific function form cannot be obtained according to the traditional statistical methods, or the precision of the model finally obtained is not ideal. Fitting accuracy refers to the evaluation of the deviation degree of the model established by historical data, which is essentially the evaluation of the sensitivity of the model to reflect the influence of all the influencing factors contained in the independent variables on the dependent variables [10]. The higher the fitting accuracy is, the higher the sensitivity of the model is, but it also means that the model may be influenced by the factors in the independent variable data that have less weight on the dependent variable. Because geometric error is the inherent error of the machine tool itself, it affects the repetition accuracy and motion accuracy of the machine tool. Error elements of CNC machine tools are shown in Figure 1.

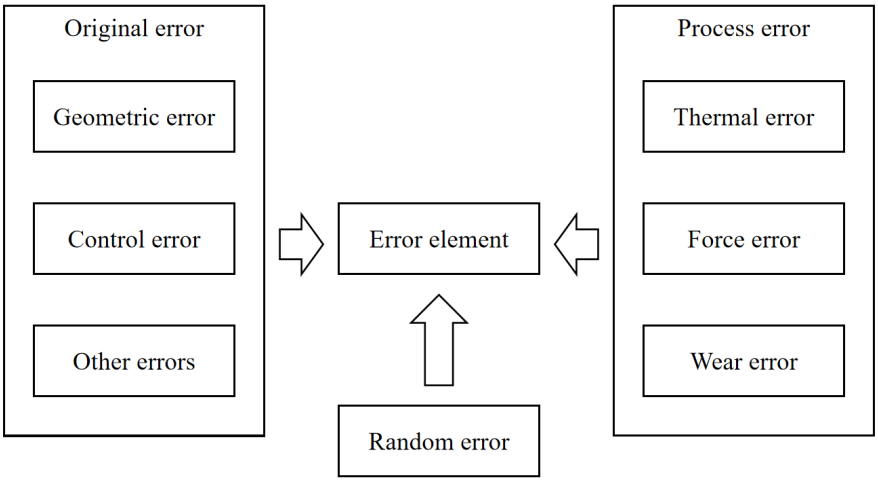

Figure 1 Error elements of CNC machine tools

Through the introduction of the in-situ detection system of CNC machine tools, we can know that the probe will have a swing angle on the plane of the machine tool. When the probe contacts the workpiece, it will immediately generate a receiving signal and send it to the receiver. However, due to the delay of the trigger signal, the probe can't get the data immediately. Under normal testing conditions, the CNC machine tool itself has an accuracy problem when it leaves the factory, and this accuracy of the machine tool is also one of the reasons that affect the workpiece testing accuracy. Because the operation of the machine tool depends on the screw pitch of the machine tool, the screw pitch operation has not reached the ideal situation, resulting in errors between the results recorded inside the machine tool and the actual position of the machine tool. Under the influence of NC machine tool error, if the parts are machined according to the ideal NC code, there will be machining error. In order to eliminate the influence of NC machine tool error on the machining process, the NC code can be modified, and the workpiece can be machined with the modified NC machining program, so as to realize the compensation of NC machine tool error. When the error compensation function is realized, the external compensation software and the numerical control

system should run at the same time, so the operation is complicated and the work efficiency is relatively low. After considering these factors, the following improvements are made, that is, the external compensation software is embedded into the numerical control system as a module, so as to improve the intelligence and integration of the numerical control system.

3. Result Analysis and Discussion

In the manufacturing of machining workshop, it is necessary to realize customized production of multiple orders at the same time, which makes the quality management of products more difficult. The finite element modeling of press frame with plate and shell element can avoid the complicated operation process and huge scale result caused by using solid element to construct this kind of structure. Machinery manufacturing enterprises are labor-intensive industries, especially state-owned enterprises. With the support of the state, many machinery manufacturing enterprises have realized information management. Then the data acquisition system and manufacturing information management system are established, but few enterprises use modern data analysis methods to process data. According to the definition of process capability, fully manage the process. After eliminating the influence of abnormal factors, the process capability is calculated from the data obtained by making the process in a stable state. According to the causes of errors in CNC machine tools, the mathematical model is constructed:

$$O_j(t) = f\left(\left[\sum_{i=1}^{n} v_{ij} x_i\left(t-\tau_{ij}\right)\right] - T_j\right) \quad (1)$$

O_j represents the output error; $f(\cdot)$ represents the neuron activation function; T_j represents the corresponding threshold of neuron j; τ_{ij} represents the corresponding synaptic delay between input and output; v_{ij} represents the corresponding weight value from neuron i to neuron j; x_i represents the input quantity, that is, the temperature parameter corresponding to the measuring point.

The geometric error of the control machine tool is a quasi-static error source, which has certain static characteristics and can be regarded as a constant in a certain ambient temperature range. It is easy to integrate with the numerical control system to realize the real-time compensation of its error. The premise for external compensation software to acquire and correct the data flow of CNC system is that CNC system should provide a data interface to realize the information interaction with external software, so it is necessary to compile the data interface. The modified NC data compensation method first calculates the error value of each machining point, corrects the coordinate value of each machining point in NC code, and takes the compensated machining point as the data of the actual machining program. Because the NC data file contains all the machining information, that is, the NC data point is the cutting position point, it is helpful to substitute the error data into the NC data to modify and generate a new NC program, which is easy to obtain higher compensation accuracy and has good versatility and operability. According to the error analysis principle of the system machining process, the real-time error information and out-of-tolerance alarm of each step in the machining process can be obtained, and hidden dangers can be checked and corrected in time. The specific process is shown in Figure 2.

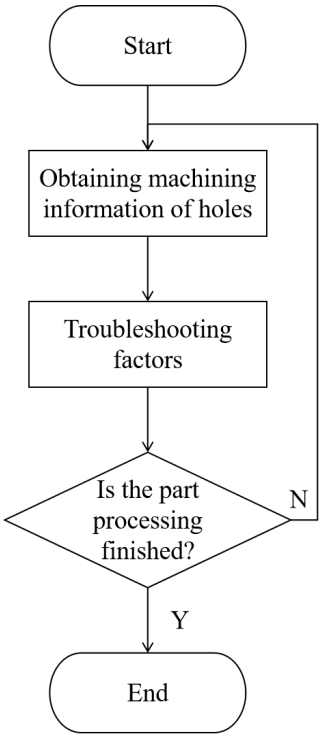

Figure 2 Algorithm flow

For important purchased equipment and raw materials, it is necessary to establish a strict out-of-warehouse quality tracking mechanism, that is, to track and manage their quality status and level in the process of production and use. The virtual error compensation system aims at the machining error of machine tools, realizes the comprehensive compensation of machining errors by modifying the workpiece coordinates, and can be applied to economical CNC machine tools with unconditional error detection or no external coordinate offset function. Without modifying the specific functions, the system functions can be changed by modifying the process model, and the process can be configured. The application logic layer also encapsulates the calling mechanism of purchasing quality management process and other quality management system processes. It can realize the integration of purchasing quality management process and the overall business process of quality management system based on workflow management platform. The parameters of the machine tool can be directly extracted from the data stream of the numerical control system, and after further processing, the error model and error elements can be introduced into the numerical control system in the form of configuration files, which has good versatility.

4. Conclusions

CNC machine tools have been developing in the direction of high speed and high precision, and the geometric error and thermal error of machine tools have played an increasingly important role with the gradual improvement of machine tool precision. When the model is applied in actual engineering error prediction, the higher the sensitivity of the model, the more serious the interference of the complex and changeable factors may be, and the prediction effect may not be ideal. However, the model has high prediction accuracy and strong robustness, so the model has better anti-interference to the changes of influencing factors. Usually, it is necessary to measure the error components produced by different error sources first, calculate the error compensation amount through the error model, and modify the theoretical numerical control instruction according to the determined error compensation amount, thus improving the machining accuracy of the numerical control machine tool. Applying data warehouse technology to NC machining big data analysis system, building Hive data warehouse, constructing different types of databases and data tables, and distributed storage and analysis of massive structured historical data can help machining decision system to mine higher data value from massive data.

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References

[1] Shi Yabei. Research on NC machining error optimization of seeder metering device based on genetic PID [J]. Agricultural Mechanization Research, 2022, 44(5):110-113.

[2] Yan Peize. Simulation of deformation error control in NC machining of special-shaped rotary parts [J]. Computer Simulation, 2018, 35(9):4.

[3] Jin Wei Fan, Wang Hongliang, Tang Yuhang. Theoretical Research on Error Modeling and Identification Technology of CNC Camshaft Grinder [J]. Vibration and Shock, 2017, 36(18):8.

[4] Xu Qi, Luo Luping, Xia Li. Research on precision reliability optimization of transmission mechanism of CNC machine tools [J]. Electromechanical Engineering, 2018, 35(10):7.

[5] Zhang Caihua. Analysis of error compensation strategy of spiral bevel gear precision NC machining [J]. Science and Technology Outlook, 2017, 27(008):56.

[6] Cui Weifang. Analysis of the causes of positioning errors in NC machining [J]. Science and Technology Innovation Herald, 2018, 15(24):2.

[7] Wang Wei, Li Qingchao, Kang Wenjun, et al. Processing performance evaluation and error tracing method of five-axis CNC machine tools based on comprehensive evaluation system [J]. Journal of Mechanical Engineering, 2017, 53(21):9.

[8] Li Hai, Li Yingguang, Cheng Yinghao, et al. Shape and position error prediction of NC machining based on machine tool geometric error model [J]. Tool Technology, 2019, 53(6):6.

[9] Li Jinglin. Analysis of the position error compensation model of CNC machining center [J]. Decision Exploration, 2020, 645(03):49-50.

[10] Han Xiaoguang, Zhai Tingting, Fu Yifeng, et al. Research on Error Analysis and Compensation Technology of NC Machining Curved Parts [J]. New Industrialization, 2018, 8(11):5.