The Application of Intelligent Manufacturing Technology in CNC Tools Design and Machining

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Abstract. CNC tool is a kind of cutting tools in industrial manufacturing. With the improvement of CNC machining accuracy and quality level, it puts forward more strict requirements for the performance of the cutting tool. Its manufacturing intelligence has become the inevitable choice for the development of the industry. In this paper, the key manufacturing technology of numerical control tools and the application of intelligence in numerical control tool manufacturing are described. The development trend of intelligent manufacturing of numerical control tools is analyzed.

Keywords: CNC Tools, Intelligent Manufacturing, Tool Design, Intelligent Diagnosis, Automatic Identification

1. Introduction
Numerical control machining technology is a very important technology in the field of modern production and manufacturing. The numerical control tool is an important part of the numerical control machining process. With the world's attention to the manufacturing industry, the numerical control knife has a rapid development. Now the manufacturing industry is in an era of change, intelligent manufacturing is the main direction of the future manufacturing industry. CNC cutting tools as a basis for machining tool, its quality, performance is directly related to mechanical product production quality and efficiency, mechanical production demanding to the production of precision cutting tool manufacturing industry to bring new development opportunities, respond to market changes, the introduction of intelligent manufacturing process flow, an upgrade has important significance to the development of cutting tool manufacturers [1].

2. Key technology of NC tool manufacturing

2.1. Tool design
In the process of tool rapid development, in order to meet the cutting performance of the best, the geometric structure is also constantly changing, the structure of the numerical control tool is ever-changing. Take the hole machining tool as an example, although there is no innovation in the general direction, some innovations in the details also have a significant impact on cutting performance, such as optimizing the shape of the cooling hole, which helps the cooling of the working part of the tool. For
drill bits, it is common to have a monolithic construction, in which the drill tip and shank are integrated. The power formula required by the motor is as follows:

\[
P_1 = \frac{FV}{1000n_1} = \frac{2300 \times 1.2}{1000 \times 0.657} = 4.38\text{KW}
\]

(1)

The formula for calculating the working speed of the drum is as follows:

\[
\eta_1 = \frac{60 \times 1000V}{\pi D} = \frac{60 \times 1000 \times 1.2}{\pi \times 360} = 63.69\text{r/mi}^2
\]

(2)

\[
n_1 = i_2 \times n_1 = (5\sim80) \times 63.69 = 318.45\sim5095.2\text{r/mi}^2
\]

(3)

According to the above calculation results, the synchronous speeds that can meet the requirements are respectively 1000r/min, 1500r/min and 3000r/min., and. In order to meet the needs, this topic selected synchronous speed motor 750r/min.

Also available in combination, the blade is mounted on the handle. For milling cutters, there are integral end milling cutters and integral ball-end milling cutters, generally used for milling complex surfaces. Taking the integral end milling cutter as an example, the cutting edge is designed as an arc, which not only lengthens the length of the cutting edge but also significantly increases the stability of the cutting edge, which can effectively improve the service life of numerical control tools [2]. In terms of numerical control tools, through the innovation of the structure, not only to greatly improve the cutting performance of numerical control tools but also to make the range of application of numerical control tools broader [3].

2.2. Tool materials
The selection of tool material is the prerequisite of tool manufacturing. The proportion of high-speed steel and carbide cutting tools is very high. At present, cemented carbide has become the first choice of NC tool material, replacing high-speed steel. At the same time, based on the cemented carbide materials, the new cemented carbide materials for cutting tools have been developed at present: nano cemented carbide, functional gradient cemented carbide, and mixed crystal cemented carbide. Such as nanometer cemented carbide is widely used in the manufacturing of micro drill field, its advantages are: high hardness and wear resistance, high strength and toughness, resulting in the manufacture of tool life is higher than ordinary cemented carbide tool. In addition, in recent years, superhard tool materials are also the focus of research, such as diamond, cubic boron nitride research [4].

2.3. Coating technology
The emergence of coating technology greatly increases the service life of CNC tools, so tool coating is also the focus of research. How to make the coating material meet the cutting requirements is the key point. The composition of coating material is different with different cutting conditions, and the composition of coating material is more and more diversified and composite [5].

3. CNC tool intelligent manufacturing technology

3.1. Intelligent design of CNC tool
As a key part of the numerical control system, the combination of numerical control tools and CAD technology significantly improves the efficiency of the tool design. All kinds of computer-aided design software are becoming more and more mature, especially in modeling design. The finite element method is applied to the research of numerical control tools, and the simulation of a cutting tool is realized, which plays a key role. In the cutting process, many factors affect the cutting performance, so we can analyze these factors through cutting simulation [6]. Figure 1 shows the application of CAD and CAE in the shape parameter design and cutting force analysis of CNC tools. Because of these advanced digital technologies, the intelligent design of CNC cutting tools becomes possible. Through customer different processing requirements, to customization tool types and the blade type custom, the acquisition of the
cutting tool production equipment key effective micro-nano production information, combined with large data make effective analysis and apply the logic of thinking, to implement the intelligence of the cutting tool design, including automatic drawing, intelligent life prediction, processing parameter optimization, and applications, Reduce the production of knives in all aspects of the cost of cutting tools.

![Tool shape design with CAD](image1)

(a) Tool shape design with CAD

![Force analysis of cutting tool with CAE](image2)

(b) Force analysis of cutting tool with CAE

**Figure 1.** CNC Tools design

3.2. *Intelligent maintenance diagnosis*

Intelligent diagnosis and maintenance refers to the use of big data analysis, machine learning, artificial intelligence, and other technologies, through the existing experience and knowledge learning, intelligent monitoring, diagnosis and prediction of the running state of the equipment, and give the repair, maintenance and improvement decisions of the equipment. Figure 2 shows the basic flow chart of intelligent diagnosis [7]. It includes not only monitoring the daily operation status of equipment and giving suggestions for maintenance and improvement but also making a judgment on the cause, location, and degree of abnormality after the occurrence of abnormality and making maintenance decisions. In the field of electronic information manufacturing, many links use tools to process products. To improve tool use efficiency and production efficiency, reduce product defect rate and production cost, the production line needs to accurately monitor or predict tool damage status online. In the actual use of the tool, there are usually: no damage state, slight damage state, moderate damage state, severe damage state four states. When the tool is cutting, different damage states produce different relative frictional force and then produce different amplitude and frequency vibrations [8].
3.3. Automatic identification technology

Common automatic identification technology includes radio frequency identification technology and two-dimensional scanning technology. The core of radio frequency identification technology is electromagnetic coupling communication. In the identification process, the reader sends a signal, and the electronic tag forms an inductive current and sends out the internally stored information in the form of electromagnetic waves. The reader receives the electromagnetic wave, and transmits it to the demodulator, and completes the final information analysis and processing in the information management system. RFID technology in CNC tool manufacturing has the following application advantages: First, longer service life. CNC tool manufacturing process tool transfer activities are frequent, the process is easy to lead to the problem of damage to the paper two-dimensional code, coupled with other external factors, may bring greater difficulties to the two-dimensional code identification, affect the efficiency of information identification. The electronic tag is set in the fixed hole, and the damage probability is greatly reduced under the protection of the outer wall, so it can be used frequently. Second, more storage capacity. The operation of reading and writing, modifying and deleting data of electronic tag is more convenient and flexible, which can meet the requirement of frequent updating of tool manufacturing information. Third, the identification speed is faster, RFID technology in the process of information identification without direct contact with the physical object, even if there are other obstacles between the identification point and the tool to be identified, can also accurately complete the identification operation [9].

The two-dimensional code scanning in the automatic identification technology will store the product information into the two-dimensional code, providing a larger information storage volume and a stronger ability to correct the information, and information identification can be completed quickly and conveniently in the production process. At present, the two-dimensional code scanning technology commonly used in the intelligent manufacturing of CNC tools includes stacked two-dimensional code and matrix two-dimensional code. The stacked two-dimensional code is composed of multiple one-dimensional codes stacked. In the matrix two-dimensional code, the dot, empty and other graphics are arranged in a certain order. In the process of identification of production information, the scanning gun can scan the two-dimensional code to accurately display relevant information. The principle is as follows: the light absorption of black and white areas in the two-dimensional code is different. After the scanning gun contacts the two-dimensional code, different light signals are formed through light reflection, and the signals are received by the conversion equipment [10].

In turn, it is converted into current signal and digital signal, and finally forms data information that can be directly referenced by the decoder analysis. In the intelligent manufacturing of CNC tool, two-dimensional code identification has become a key link. At the early stage of the application of this technology, printing and pasting paper two-dimensional code are used to identify the two-dimensional code, which is prone to lose and damage of the two-dimensional code and lead to the problem of
information identification error. At the present stage, two-dimensional code recognition technology has been significantly developed, has been able to achieve laser scanning tool identification.

4. The development trend of CNC tool intelligent manufacturing

4.1. Manufacturing platform that can be infinitely upgraded

Compared with the processing and manufacturing of other large products, the research and development time of CNC tool products is short, whether it is the introduction of new equipment or the introduction of technology are more frequent, therefore, a more common problem is that the production line on each process link there are many technical upgrading problems. Connect the production unit is just beginning, the existing production lines technology upgrade, the existence of old and new equipment to reset, and upgrade the problem, and to achieve the ideal state, it is necessary to build scalable platform, if the same equipment suppliers before and after introducing new equipment system, or the system introduced by compatibility is not strong, will create new problems. Therefore, the intelligent numerical control tool to build a complete can be an infinitely upgraded manufacturing platform. For example, the INC intelligent system can use various sensors such as temperature to obtain data sources, and the most important thing is that the cloud housekeeper module can complete relevant deployment without the need to upgrade the system. In addition, some manufacturers have integrated ERP, PLM, and other software developed on various platforms and applied it to cloud computing platforms, and built open interfaces to promote the development of manufacturing technology [11].

4.2. Combination with 5G technology

5G is the latest generation of cellular mobile communication technology. The biggest feature of 5G is to promote mass interconnection between human and physical objects, with large bandwidth, low latency, and high reliability. It not only has the prospect of consumer applications but also supports the development of the real economy. The core connotation of the industrial Internet is digitalization, networking, and intelligence. The 5 G-enabled industrial Internet will give birth to a new industrial ecosystem, and the integration of the two will promote the high-quality development of the manufacturing industry. 5G+ Internet of Things technology is used to connect devices to provide massive industrial real-time data and build a think tank of industrial mechanism model; Optimal allocation of total factor resources is realized through the efficient coordination of R&D, design, manufacturing, and operation management. In order to solve the common problems in the precision tool industry, such as long research and development cycle of new products, long adjustment and correction time, excessive reliance on manual experience, low efficiency of manual sampling, high cost of tool use, extensive tool life management and so on.

5. Conclusion

In modern and diversified industrial applications, different industries and different enterprises have different requirements for CNC cutting tools. This brings new challenges to the design and manufacture of NC cutting tools. the development and application of intelligent manufacturing and processing technology to promote the development of the CNC tool manufacturing industry, in line with the requirements of the manufacturing industry for CNC tools. With the development of various advanced technologies and the integration of computer technology and other technologies, the outline of intelligent manufacturing is gradually improved, further promoting the development of the future manufacturing industry.

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