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The application of CNC machining technology in mechanical mold manufacturing

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Abstract: *With the development of modern manufacturing industry, the application of CNC machining technology in mold manufacturing is more and more extensive. This paper mainly discusses the traditional application of CNC machining technology in the field of mechanical mold manufacturing. Through the introduction of high-speed CNC machining technology, composite CNC machining technology and CNC EDM technology, its potential in improving manufacturing efficiency, reducing costs and improving product quality is deeply analyzed in combination with actual reform cases. The analysis shows that the application of NC machining technology in the process of mold manufacturing can improve its efficiency, precision and quality. Through literature review and case analysis, the paper aims to provide valuable guidance and inspiration to promote the wide application and further research of CNC machining technology in mold manufacturing.*

Keywords: *Numerical control machining; Mold manufacturing; Apply; innovate*

1. Introduction

Mold manufacturing is a key link in industrial production, the quality and precision of the mold has an important impact on the molding and quality of the product, as an indispensable tool in modern manufacturing, its quality directly affects the quality of the product and production efficiency. CNC machining technology has the characteristics of high precision, high speed, high efficiency and so on. Processing by computer controlled machine tools can greatly improve the manufacturing quality and efficiency of molds, reduce production costs, and improve the production efficiency and service life of molds. With the continuous development of CNC machining technology, the application in mold manufacturing is more and more extensive. At the same time, with the continuous emergence of new materials, CNC machining technology is also constantly developing and innovating, providing more possibilities for mold manufacturing.

2. The traditional application of NC machining technology in mold manufacturing

2.1 Research status at home and abroad

Numerical control (CNC) is a technology that uses information technology to control machinery through information programs to realize automatic program control of machine tools and complete mold processing [1]. Compared with traditional manual operation or mechanical control, CNC machining technology has higher accuracy, higher efficiency and greater flexibility.

Xie Qiang, Wang Fengda, Liu Hanyang et al[2]. conducted a comprehensive study on the formulation, positioning, selection of clamping schemes and selection of cutting tools of metal materials. According to the characteristics of CNC high-speed cutting technology, they applied it in the processing of large aluminum alloy wall panels and slide rib parts, and the qualified rates of the output parts were 98.46% and 97.65% respectively; Zhang Xiaobo[3] from Zhejiang University, starting from the manufacturing perspective of Invar steel composite integral inlet die, studied the forming process of the die by using artificial neural network, genetic algorithm and finite element simulation method, and obtained a better combination of process parameters through experiment and simulation optimization, so as to realize high-precision machining of the composite integral inlet die; Wang Xinwei [4] from Nanjing University of Aeronautics and Astronautics proposed an EDM scheme and designed a simulation system to improve machining accuracy and efficiency by combining digital manufacturing technology and EDM for the machining of closed integral impeller. It mainly includes the geometric

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simulation analysis of impeller runner, the interpolation algorithm of electrode motion trajectory, and the development and design of numerical control EDM simulation system.

WangZhijie; GorbachevSergeyr et al[5] used finite element analysis to simulate the conventional and high-speed cutting behavior of 7075-T6 aluminum alloy, established the JohnsonCook constitutive model, and studied the influence of parameters on the simulation of cutting force by comparing the predicted cutting force with the experimental results. The results show that the selection of model parameters is different under different cutting conditions. The model is suitable for predicting machining properties, but accurate experimental data are needed to determine material constants; JingjieGuo; GuoJingjie et al [6] adopted the mixed processing technology of CNC lathe and four-axis machining center in view of the complex processing technology and high precision requirements of the shell on the electro-hydraulic servo valve. Roughing and machining is carried out by CNC lathes, then finishing is carried out on CNC lathes and four-axis machining centers, tool paths are designed using 3D CAD models, and G-codes are generated for machining. The results show that the optimized process can improve the machining efficiency and precision; KumarSudhir et al [7] used Taguguch-grey correlation analysis (T-GRA) to optimize and analyze the parameters of MCV, and determined the optimal method position through verification tests, proving that T-GRA technology greatly enhanced multiple performance characteristics of DS-EDM method.

2.2 Limitations and challenges of traditional CNC machining in mold manufacturing

Traditional CNC machining has some limitations in mold manufacturing, such as limited machining capacity for complex shapes, relatively slow processing speed, deformation and surface quality problems caused by cutting heat.

The machining ability of complex shapes is limited, and the processing accuracy needs to be improved: the traditional CNC machining technology has certain limitations in the processing of complex shapes, and it is difficult to meet the processing requirements of specific curves or surfaces. In mold manufacturing, due to the impact of tool wear, cutting force changes and other factors, it is difficult to achieve high-precision machining, which is a problem that needs to be overcome.

The processing speed is relatively slow, and the production efficiency needs to be improved: in mold manufacturing, it is important to achieve efficient production to improve the competitiveness of enterprises. In the process of traditional CNC machining mold parts, the improvement of the cutting speed of the machine tool is limited by the rigidity of the machine tool and the cutting performance of the material, resulting in the processing speed cannot be greatly improved, and it is difficult to meet the production needs of large quantities and high efficiency, thus limiting the improvement of production efficiency.

Thermal damage in the cutting process, the processing capacity of composite materials is limited: in CNC machining, a lot of heat will be generated when cutting, which is easy to lead to thermal damage to the tool and the workpiece, affecting the processing accuracy and surface quality. Special materials and composite materials, which are widely used in modern mold manufacturing, have higher hardness and complexity than traditional materials, and traditional CNC machining technology faces challenges in processing these materials, requiring targeted innovative solutions.

3. The innovative application of CNC machining technology in mold manufacturing

3.1 Application of high speed CNC machining technology in mold manufacturing

High-speed nc machining technology (HSCNC) is a high-speed machining technology in the field of nc machining[8]. It combines numerical control technology and high-speed machining technology to achieve faster and more accurate machining results.

High-speed CNC machining technology is very important for mold manufacturing, because the size and surface quality of the mold are required to be very precise. The use of high-speed rotating tools and feed speed can improve the cutting speed and processing efficiency, thereby shortening the processing time and improving the production efficiency. With cooling lubricants, it can reduce the cutting heat in the cutting process, reduce the thermal damage of the tool and the workpiece, extend the service life of the tool, and reduce the number of tool replacement, improve the processing quality and the economic benefits of mold manufacturing.The phenomenon of high-speed cutting is shown in Figure 1 and Figure 2:

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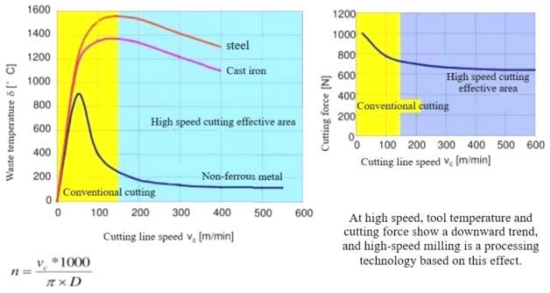

Figure 1 Relationship between tool temperature and cutting force in high-speed cutting

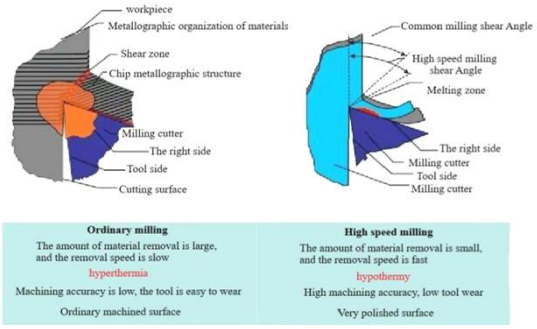

Figure 2 Comparison between ordinary milling and high-speed milling

The following is a case of mold production reform using high-speed CNC machining technology:

After A company adopted high-speed CNC machining technology reform, the production efficiency was significantly improved, and the processing efficiency was increased by 30% on average. Taking a certain model of mold as an example, before the reform, each mold processing takes more than 15 days, and after the reform, it only takes an average of 10 days to complete the processing. At the same time, the mold processing accuracy and surface quality after the reform have also been significantly improved. The introduction of high-speed CNC machining technology needs to invest a large transformation cost, including machine tool equipment and technical training. However, due to the improvement of processing efficiency, the order capacity has been rapidly improved, the production input-output ratio has also increased, and the reform cost has been rewarded.

3.2 Application of composite CNC machining technology in mold manufacturing

Composite numerical control machining technology is the traditional nc machining technology combined with other processing technology, in order to achieve more advanced, multi-function and complex shape workpiece processing of a kind of technology. By integrating different processing processes, machine tools and tools, it makes it possible to complete a variety of different processing operations on the same CNC machine, thereby significantly improving production efficiency and product quality.

Composite CNC machining technology is often used in the field of mold manufacturing, because the manufacture of complex shapes of molds usually requires several different processing steps, such as roughing, finishing, finish processing, etc. In the traditional mold making process, many different machine tools are usually required for processing operations, and the composite CNC machining technology can complete these operations on the same machine tool, which greatly simplifies the mold making process and improves the production efficiency.

The composite NC machining integrates many different machining technologies together, which has wide application and important significance in the field of mold manufacturing. Combined with high-speed cutting technology, ultra-precision machining and multi-axis linkage machining, higher machining accuracy and surface quality can be achieved, improving the durability and manufacturing accuracy of the mold. At the same time, combined with laser processing, sensors and automation devices and other technologies, can achieve non-contact processing, rapid positioning, automatic tool change and automatic repair functions, further improve production efficiency and automation level.

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This technology can effectively deal with complex composite structures and shapes, greatly improve production efficiency and product quality, reduce tool reversing time, shorten processing time, and ensure high quality and dimensional accuracy.

The following is a high-precision mold manufacturing case using composite CNC machining technology:

After B company adopts composite CNC machining technology to manufacture molds, compared with traditional processing technology, mold processing accuracy has been improved, the accuracy is less than 5 microns, and the surface quality has also been greatly improved. Compared with a certain model of mold, the quality of the mold produced by composite CNC machining technology not only meets the mold change standards, but also increases the life of the traditional mold by about 30%, which greatly reduces the frequency of mold change and maintenance costs.

3.3 Application of NC EDM technology in mold manufacturing

Numerical control EDM technology is a kind of use of edm discharge principle of metal cutting processing of advanced manufacturing technology. By applying a pulse power supply between the conductive workpiece and the electrode, it realizes the corrosion of the workpiece and completes the machining of the parts [9]. The discharge process is controlled by numerical control system, which controls discharge time, discharge energy, discharge position and other parameters, so as to achieve accurate machining results.

Nc EDM technology can process complex internal and external shapes, such as spiral holes, fine structures and so on. Small machining tasks that are difficult to achieve in traditional machining can be achieved with high precision and high efficiency through EDM technology. When the mold is damaged or needs to be repaired, CNC EDM technology can repair the damaged part and restore the original size and shape of the mold. In addition, for the case of mold loss caused by long-term use, the mold can also be repaired using EDM technology to restore its function and quality. It can achieve high-precision cutting and processing on hard materials that are difficult to cut in traditional machining, providing more material choices for mold manufacturing.

The following is a mold improvement case using CNC EDM technology:

C company manufactures the injection mold of mobile phone shell. Due to some defects in the manufacturing process of the mold, the appearance of the product is not refined enough and needs to be improved. After analysis, these defects are mainly caused by slight uneven inside the mold. To solve this problem, the company uses CNC EDM technology to process mold parts. By controlling the machining process through the numerical control system, the concave and convex inside the mold can be more stable, resulting in a more refined appearance. After the improvement, the company's mobile phone shell injection mold has reduced the production scrap rate by nearly 30%, not only improving production efficiency, but also reducing production costs and increasing the company's profits. This also provides experience and reference for the company to use CNC EDM technology for mold manufacturing in the future.

4. The method of improving the precision of CNC machining of mechanical die

4.1 Geometric error control

Design optimization: In the mold design stage, it is necessary to optimize the geometric structure of the mold as far as possible according to the needs and process requirements, and reduce the design difficulties and error sources.

Precision Machining: it utilizes high-precision CNC machining equipment, and selects appropriate cutting tools and cutting parameters to ensure geometric accuracy during the machining process.

Accurate measurement: it uses precision measuring tools to measure the workpiece accurately and find and correct geometric errors in time.

4.2 Machining operation control

Tool selection: Processing personnel should choose suitable cutting tools before processing, including tool material, geometric shape, and tool radius, to ensure stability and accuracy during the

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processing.

Tool grinding: The person in charge of equipment maintenance regularly grinds and maintains the cutting tools to ensure their sharpness and geometric accuracy.

Control of Machining Parameters: Equipment management personnel should reasonably select parameters such as cutting speed, feed rate, and cutting depth to avoid vibration and overheating, and ensure machining accuracy.

4.3 Heat control

Temperature stability: During the machining process, the machine tool and workpiece should maintain a stable temperature as much as possible. The use of control equipment such as cooling systems and temperature compensation devices can reduce size changes or deformations caused by heating.

Heat treatment with: For the mold material that needs heat treatment, pre-treatment should be carried out according to the requirements of the heat treatment process to reduce the influence of heat treatment on the accuracy of the mold.

4.4 Force control

Clamping force control: Reasonable selection of fixtures and clamping forces in the processing technology ensures reliable clamping of the workpiece during the processing, reducing vibration and deformation.

Tool Path Optimization: The cutting path of the mold should be more optimized, reducing the concentration and variation of cutting force, and reducing the stress impact on the workpiece and mold.

Cutting force monitoring: The use of force sensors and other equipment to monitor the force in the cutting process in real time, timely adjust the processing parameters, to avoid too much or too little force in the processing.

5. Conclusion

The application of CNC machining technology in mold manufacturing has achieved remarkable results, and the efficiency, accuracy and quality of the manufacturing process have been improved by introducing high-speed CNC machining, composite CNC machining and CNC EDM technology. CNC machining makes mold manufacturing more flexible and accurate, meets the rapid changes in customer needs, reduces production costs, improves production efficiency and product quality, and enhances the competitiveness of enterprises.

The application prospect of CNC machining in the field of mold manufacturing is broad, with the continuous progress of technology, CNC machining technology will further improve the efficiency and accuracy of mold manufacturing, and expand more application fields. The development of emerging technologies such as 5G, artificial intelligence, and big data provides more possibilities for the application of CNC machining technology, and the wide application of new materials will also promote the development of CNC machining in mold manufacturing. However, CNC machining still needs to face some challenges and further research directions. Improving the accuracy and stability of CNC machining technology, strengthening the combination with other related technologies, researching new equipment and processes to adapt to the mold manufacturing needs of different materials and shapes, and strengthening industry-university-research cooperation are all important directions for future development.

In summary, the application and innovation of CNC machining technology has brought more possibilities for mold manufacturing, with the continuous development of technology, the application of CNC machining in mold manufacturing will be more extensive, and promote the continuous upgrading and transformation of the manufacturing industry.

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