Application of high-speed cutting technology in automobile manufacturing

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Abstract. High-speed cutting technology is widely used in stamping die, die-casting die and injection die for its high processing efficiency. Based on the characteristics and advantages of high-speed machining technology, this paper analyzes the application of high-speed machining technology in the manufacture of automobile parts, overlay parts, cylinder bodies and automobile wheels, taking the change of cutting speed and cutting temperature as the research object.

1. Introduction
In modern industrial manufacturing, mold manufacturing has become an important way of automobile production, but due to the high precision requirements of the inner surface of the mold, and a long manufacturing cycle, which affects the development of products, resulting in a decline in corporate profits. The emergence of high-speed cutting technology simplifies the process of automobile mould manufacturing and shortens the production cycle, so that enterprises can quickly adapt to the changeable competitive environment and enhance the vitality of enterprises. Compared with the traditional machining method of high-speed cutting technology is cutting processing has been greatly improved, the same time the amount of metal cutting than the traditional machining increase by 40%~50%, and because of high-speed cutting spindle speed makes the chip with a lot of heat, can make the workpiece thermal deformation smaller, improve product quality [1]. Therefore, high-speed cutting technology is a very important production method in automobile mould manufacturing.

2. Status of high-speed cutting technology
2.1. The status quo abroad
One of the first Missiles developed by German scientists in the 1930s was Missiles at high-speed Missiles and Space corporation in 1970, which developed high-speed Missiles for practical production. Subsequently, the major industrial countries are strengthening the research and development of high-speed cutting technology, so that high-speed spindle, fast feed system, ultra-hard ultra-wear-resistant materials and CNC system made great progress. Each big car company abroad to make cars, now commonly used high-speed cutting technology in Germany's Volkswagen, for example, Volkswagen cylinder body, interior mold and instrument panel mold and other large plane processing are used in high-speed cutting technology, greatly improved the productivity of Volkswagen and qualified rate, reduce the cost, save the energy consumption. The five-axis high-speed cutting center developed by Swiss company Miccoli uses a high-weight marble material as the body of the high-speed cutting center, which can greatly reduce the vibration generated during production and improve the quality of
processed parts. German Siemens company also developed the overall structure of the o-shaped 5-axis high-speed cutting center, so that the quality of high-speed cutting parts to be further improved. The application of high-speed cutting technology has greatly promoted the development of high-speed cutting technology. The Hyper Mach five-axis machining center made by Cincinnati Milacron in the United States is highlighted. The spindle speed of high-speed cutting can reach 60000r/min, the maximum feed speed can reach 100m/min, and the power of the spindle is up to 80kw.

2.2. The domestic status quo
Domestic high-speed cutting technology started late, most of the enterprises are dependent on foreign imports, and late investment in less, the development of high-speed cutting technology growth is slow, and there is a big gap with foreign countries [2]. China's high-speed cutting technology has the shortcomings of basic research, poor processing technology, etc., with the introduction of advanced foreign high-speed cutting center at the end of the 20th century, the rapid processing technology has been rapid development, so that the machining cycle greatly reduced, but domestic enterprises has been the use of standardized tools tool, not the innovation research on cutting tools, although has been the introduction of some foreign advanced equipment, but the total equipment is not enough, most common tool used in production line, so Chengdu Tool Research institute and Shanghai Research such as the strengthening of high-speed cutting tool technology, the cutting tool materials and processing technology for the high-speed cutting technology has improved, and has been for aerospace products. High-speed cutting technology has become one of the most important subjects in universities.

3. Analysis of high-speed cutting technology

3.1. Characteristics of high-speed cutting technology
As one of the most important advanced manufacturing technologies in mold manufacturing, high-speed machining is an advanced manufacturing technology with high efficiency, high quality and low consumption. A series of problems in conventional machining have been solved by the application of high-speed machining. Its cutting speed and feed speed are greatly improved compared with the traditional cutting processing, which has the following characteristics:

(1) High processing efficiency; compared with traditional machining, high-speed cutting technology can improve the material removal rate by 30%~50% and improve the mold production efficiency by 5~10 times, increased product productivity [3].

(2) Lower cutting force, less cutting heat; when high-speed cutting is carried out, the cutting force decreases with the increase of speed. Because of the high-speed cutting chip with more than 90% of the heat, so the temperature will reach the peak will reduce, when the temperature drops to a certain extent, the temperature remains the same, can reduce the thermal deformation of the workpiece processing, suitable for precision parts processing [4]. Take soft aluminum as an example. When the cutting speed reaches 240m/min, the cutting temperature of aluminum reaches its peak. If the cutting speed continues to increase, the cutting temperature of aluminum will decrease.

(3) The processed surface is of high quality; because the high-speed cutting force is small, in the high-speed cutting of the workpiece surface has been polished, so the surface quality has been processed high, do not need secondary processing [5].

(4) Reduce energy consumption and save energy; the high-speed cutting technology reduces the processing time by nearly half compared with the conventional processing, and maintains the quality, reduces the energy consumption, as shown in Figure 1.
3.2. Selection of tool materials for high-speed cutting technology

High-speed cutting, the need for a high spindle speed, a large amount of feed, therefore, high-speed cutting technology used by the tool put forward higher requirements. In the process of commonly used mold materials for the selection of tool materials for coating cemented carbide, has a high cost performance, so the scope of the most widely applicable; When machining die steel with rockwell hardness (HRC) less than 50, the tool material used is ceramic, with the advantages of stable chemical properties, good wear resistance, high cutting speed and low price, but its hardness and toughness is low, easy to wear [6]; Cubic boron nitride (CBN) and diamond are selected as the cutting tool materials in the processing of hardened die steel, chilled cast iron and titanium alloy, etc., with high hardness, ultra-high wear resistance, stable chemical performance and good thermal conductivity at high temperature, but the price is higher. The type of tool to be used should be set in combination with the parameters of the material to be machined, as shown in Table 1.

Table 1. High-speed milling cutting tools and parameters.

| The workpiece material | Cutting speed (m/min) | Feed rate (m/min) | Tool/coating                  |
|------------------------|-----------------------|-------------------|-------------------------------|
| aluminum               | 2000                  | 12 ~ 20           | Solid carbide tool/uncoated   |
| copper                 | 1000                  | 6 ~ 12            | Solid carbide tool/uncoated   |
| Steel (HRC400)         | 400                   | 3 ~ 7             | Solid carbide tool/tich-tiale coating |

4. Application of high-speed cutting technology in automobile mould manufacturing

4.1. The method of high-speed machining technology in automobile mold manufacturing

High-speed processing technology and traditional processing technology, processing technology is very different, the use of conventional processing spindle speed is low, slow feed, single stroke; high-speed machining technology USES high-speed spindle, fast feed, multiple stroke [7]. In order to achieve high-efficiency machining, high-speed machining technology needs to adjust the parameters required for machining, including cutting tools, cutting quantity and feed speed required for high-speed machining. In the process before the need to specify a good process path, especially for the development of the processing order, to ensure the accuracy of the processing parts to meet the requirements, choose a reasonable tool path and tool change times. CNC equipment needs to have a
high speed, and the machine itself needs to have good rigidity and stability, in order to meet the needs of rough machining and finishing; High precision feed system is needed to prevent the cutting tool from leaving scratches on the workpiece surface and damaging the quality of parts. It is necessary to plan the machining path and make a reasonable cutting route to reduce the cutting times and improve the machining accuracy. Therefore, the processing methods of various stages using high-speed machining technology in automobile mold manufacturing are as follows:

(1) Rough machining stage, the main purpose is to remove 90%~95% of the material in a short period of time, it is appropriate to use large feed speed and large cutting amount, the first processing out of the mold outline. In this stage, the cutter cutting and cutting need to use the arc trajectory, in order to prevent breaking the cutter and damaging the mold in the heavy cutting [8].

(2) In the semi-finishing stage, the main purpose is to adjust the mold contour, it is appropriate to use small feed speed and small cutting parameters, remove burr and flash produced during rough machining and further adjust the size of the automobile mold. In this stage, the machining should have allowance for finishing, and the cutting amount should be calculated during the semi-finishing to ensure the subsequent processing.

(3) During the finishing process, the main purpose is to polish the final size and surface of the mold, and the micro-feed speed and micro-cutting amount should be adopted to make the precision and surface roughness of the mold reach the required requirements. In this stage, the depth of each cutting should be strictly calculated to reduce the number of times of raising and dropping the tool as much as possible. In addition, when the tool cuts into the surface of the workpiece, the circular arc method should be used to ensure that the surface quality of the workpiece will not be interrupted during the cutting process. In the same way, when cutting the workpiece surface, it is also necessary to use circular arc to avoid falling scratches on the workpiece surface [9], so that the precision and smoothness of the workpiece are affected, so that the quality of the workpiece can meet the requirements.

4.2. High-speed cutting of automobile parts molds
The molds used to process automobile parts mainly include the instrument panel, cover piece, wheel hub and cylinder block, etc. When high-speed cutting technology is adopted, the machining effect, method and advantages are shown as follows:

(1) Irregular parts mold processing. High-speed cutting has better effect on hard material cutting. In the manufacture of automobile parts molds, often need hundreds or even thousands of molds, in order to shorten the manufacturing cycle of automobile parts molds, and reduce the manufacturing cost of automobile molds, therefore, high-speed cutting technology will be the first choice of automobile parts molds manufacturing technology. For the irregular parts such as the instrument panel, central control board and interior decoration board, the mold is usually used for production. However, the shape of the inner cavity of these molds is complex, which is difficult to be processed by the traditional processing method. The above problems can be solved by high-speed cutting method. High-speed cutting technology in the shape of irregular parts mold processing, fully presents the following advantages: ① The precision of automobile parts mould is high; ② In the high-speed cutting of a single cut is small; ③ Can be fast multiple cutting; ④ Reduce the second trimming, processing finished products of high quality; ⑤ Improve the processing efficiency.

(2) Cover mold processing. Most of the covers are made up of various curved surfaces. The use of a high-speed cutting center enables the production of covers with high precision grade, long service life, and in large feed speed, high-speed cutting center can provide high-precision positioning and high-precision interpolation. When the automobile engine cover mold is processed, because the cover mold needs to have high tensile strength, compressive strength and high precision, therefore, in the process of the cover mold, usually a large number of complete blank material removal, to ensure the quality of the mold. Using high-speed cutting technology for processing, using high-speed cutting technology to cover the mold processing has the following advantages: ① High spindle speed and fast
cutting can ensure the roughness of the mold to meet the quality requirements; ② high-speed cutting speed, micro feed and the precision of multiple cutting, can meet the technological requirements of covering parts mold production, so that the overall mold processing efficiency has been improved.

(3) Cylinder mold processing. The application of high-speed cutting technology can reduce the production cycle of cylinder block mould and improve the quality of cylinder block mould. Now, car manufacturers are using high-speed cutting center to make cylinder mould, including Shanghai Volkswagen using high-speed CNC drilling for engine cylinder block and cylinder head die mould technology for high-speed cutting, such as the processing of cylinder body mold and the cylinder head mould can a molding, and concrete of high accuracy, can reduce cylinder mould manufacturing process, shorten the production cycle [10].

(4) Wheel hub mold processing. Using high-speed cutting technology can quickly produce automobile wheel hub mold, can ensure the precision and quality of automobile wheel hub produced by the mold. Due to the complex shape of automobile wheel hubs, the use of traditional processing methods is time-consuming and laborious, with low production efficiency, and the accuracy requirements of the processed automobile wheel hubs are difficult to ensure as shown in Figure 2. Therefore, the use of molds to manufacture automobile wheel hubs is a common method adopted by many enterprises. When using the conventional way to process the mold hole, it needs more than one working procedure and more than one machine tool to process, which wastes time and energy. The application of high-speed cutting technology in the machining of mold holes of automobile wheel hubs also has great advantages. High-speed cutting method can simplify multiple processes and multiple machine tools, as shown in Figure 3.

![Figure 2. Traditional processing.](image1)

![Figure 3. High-speed cutting center.](image2)
5. Conclusions
High speed machining technology has an irreplaceable position in automobile mold manufacturing due to its high efficiency and high quality processing advantages, and will play a leading role in the field of mechanical processing. In this paper, aiming at the application of high-speed cutting technology in automobile mold manufacturing, the methods and conclusions proposed and obtained are of great value, especially for the application of high-speed cutting of automobile parts with complex shapes, covering parts, wheel hubs and cylinder blocks. It improves the machining efficiency, precision and surface quality of the mold and improves the stability of the production process structure as a whole. High speed machining technology can reduce energy consumption, improve efficiency and save cost.

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