Application of Green Manufacturing Process in Cutting

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Abstract. Reducing the consumption of resources by traditional manufacturing industries and avoiding environmental pollution caused by traditional manufacturing industries is one of the major problems facing the manufacturing industry in the new century. Nowadays, countries adopt a sustainable development strategy, which is about the manufacturing cycle of products around green manufacturing. Green manufacturing is the only way for sustainable social development. It plays an important role in equipment manufacturing, national defense security and the national economy. In this paper, the use of traditional and green processing technology in the key machining process is analyzed, and the evaluation method of quantitative measurement of green manufacturing process elements is deeply studied. Through the analysis, optimization and evaluation of raw material loss, auxiliary materials and energy consumption, pollutant discharge and other factors in the engine machining process planning, this paper has achieved the greening of mechanical processing and mechanical processing of other parts. Have a certain guiding significance.

1. Introduction

1.1. The background and significance of the topic
Since the beginning of the 21st century, human society has produced three major changes. The first is the rapid development of science and technology, which has greatly increased productivity, expanded the scale of the world economy, and enabled humanity to gather a large amount of wealth and make human civilization stride. Advance; second, the population growth, the end of the 20th century. The total population of the ball has reached 6 billion, and it is still a spurt of growth. Third, the development of human resources on the earth has intensified, resulting in the massive discharge of three waste pollutants, so that global material shortage and environmental pollution, the ecological environment has had a bad impact.

1.2. The main research content of this paper
Through the application analysis of the traditional machining process and the green manufacturing process in the key machining process, combined with the characteristics of the dry machining, the opinions and suggestions on the selection of the machining tool are put forward, and the machine structure is optimized and analyzed.
2. Application of green manufacturing process in cutting

The most obvious distinction between the traditional processing technology and the green manufacturing process lies in the utilization of the cutting fluid. In the traditional processing technology, the cutting fluid is indispensable, it needs to have good cooling performance, lubrication performance, anti-rust performance, degreasing cleaning function, anti-corrosion function, easy to dilute and so on.

The amount of cutting fluid used is proportional to the processing time. The longer the machining time, the more the cutting fluid is used. However, cutting fluid is one of the main sources of contamination for machining.

First, the waste oil and waste liquid remaining after the cutting fluid has been processed must be treated through a series of effective treatments, and if it is directly discharged or incinerated, the discarded oil will produce toxic substances. Second, cutting fluids also affect human health and personal safety. In addition, additives in the cutting fluid may cause corrosion, rust, etc. on the equipment, and may increase frictional factors on the sliding surface and cause unsafe factors such as fire.

Moreover, the more the cutting fluid is used, the more the cutting fluid is adhered to the processing equipment, tools, and workpieces, and the corresponding post-processing is more troublesome.

For the above reasons, the green processing process in machining should be based on the method of not using cutting fluid or using less cutting fluid.

2.1. Quasi-dry processing

In some special processes, it is difficult to completely abandon the cutting fluid, at least in the current technical capabilities, such as drilling deep holes, whole tapping and so on. In this case, a small amount of lubrication or a low-temperature air-cooled quasi-dry cutting method can be used.

The low-dose lubrication method can also be called spray lubrication. It atomizes a small amount of lubricant and then sprays the atomized lubricant at high speed to the cutting area through a series of equipment to achieve cooling, lubrication and chip evacuation. And so on. The atomized lubricant is used in the same amount of tens of thousands of wet machining fluids as the wet machining fluid, compared to the cutting fluid used in conventional wet machining.

Reducing the amount of lubricant also means reducing environmental pollution, while post-processing machine tools, tools, workpieces, chips, etc. have many advantages, improve work efficiency, reduce labor intensity and improve the working environment.

Low-temperature air-cooled cutting is a cutting method that uses low-temperature air instead of conventional air to achieve cooling and lubrication purposes based on spray lubrication. The service life of the turning tool using this cutting method is more than twice the life of the turning tool under normal use.

2.2. Dry processing

Dry machining includes both dry and dry grinding processes.

(1) Dry cutting

Not involved in dry cutting: Cutting fluid it is an environmentally-friendly clean manufacturing process. It is a new type of green manufacturing technology. It not only minimizes environmental pollution, but also eliminates the need for cutting fluid to set up the relevant equipment. Cost of production significantly reduced.

Dry turning, dry milling, dry machining, etc. are all in the category of dry cutting. Dry turning is a common technique in dry cutting. Dry cutting has a good application in many materials processing fields, especially for the processing of non-ferrous metals and alloys. Higher temperatures are produced during dry cutting and therefore have higher requirements on the heat resistance and wear resistance of the tool. Therefore tool selection is crucial.

Dry cutting requires that the tool material not only have high red hardness and thermal toughness, but also good wear resistance, thermal shock resistance and hot tack resistance. Higher requirements for tool materials, coating technology, tool structure and geometry.
The geometrical angle and structural design of the tool must meet the requirements of cutting for chip breaking and chip removal. Choosing the right tool structure and suitable geometric angle can not only inhibit the cutting force from being too high, but also reduce the cutting force. Built-up edge produces, reduce cutting temperature, as well as chip breaking and control chip flow.

Tool selection can be considered in two ways: tool material and coating. High-speed steel, hard alloy (including cermet), ceramic, PCD (polycrystalline diamond), the hardness is gradually increasing, the cutting speed can be gradually increased. In contrast, ceramics have a better price/performance ratio than CBN. Therefore, the development of various new ceramic materials is the focus of current research. Such as whisker toughening ceramics, this ceramic is formed by adding 20% to 30% of SiC whiskers on the AlO matrix, which can greatly improve the toughness of the tool. For example, ceramics with elements such as Si and N are also added. Features. The current cermet materials are mainly TiAlN cermet plated hri7 and TiN sodium rice powder modified cermet. These two ceramics can only be used in finishing and semi-finishing because of their poor impact resistance.

Low price, high strength and toughness, high recovery steel and hard alloy are the main tool materials currently used in production. The limitation of this material is that it must be used with cutting fluid, otherwise the surface is very easy to wear. This results in a shortened tool scrapping cycle. But this tool can be improved by coating technology.

The overall performance, coating technology can improve the friction between the tool and the workpiece, the chip, reduce the wear of the tool, which can also be applied to high-speed dry cutting.

The dry cutting tool technology of the coating is also a new development technology. It is applied to ordinary high-speed steel and carbide tools, and is applied to single or multi-layer special materials under high temperature and high pressure conditions. The coated tool can still exhibit better anti-wear and anti-wear properties; at the same time, the coating can also generate thermal insulation between the tool and the chip to improve the heat resistance of the tool; in addition, the coating technology can effectively protect the chemical reaction of the tool material.

Once the tool material is selected, the tool geometry needs to be optimized. The purpose of optimization is to reduce the unit friction area of the surface of the tool and the workpiece, reduce the cutting force, reduce the cutting heat, reduce the cutting temperature, reduce the tool wear and prevent the formation of built-up edge.

(2) Dry grinding

The traditional grinding process has a great influence on the environment. The oil fumes generated during the processing are discharged into the air, and the discarded grinding fluid after processing is not easy to handle. Strong cold air grinding technology is a commonly used dry grinding process. It is sprayed in the processing area after cooling the air to a certain temperature to form a certain low temperature effect. This low temperature effect will cause the workpiece to be ground during grinding. The sparking phenomenon occurs on the noodles, which reduces the thermal deformation generated during processing.

2.3. Green optimization design of dry machining machine structure

The most important part of the optimization design of the machine tool structure is to reduce the influence of thermal deformation on the machining. The friction heating, the unstable tool temperature and the smooth heat transfer of the cutting machine are all important factors for the thermal deformation of the machine tool. At the same time, avoiding the secondary damage caused by the discharge of chips is also a key aspect of machine tool structure optimization.

(1) Error compensation system: The machine tool spindle box and machine tool column are the places that need to be paid attention to. If the temperature is too high, the spindle box or column will be thermally deformed, which will definitely have a great impact. At this time, it needs to be offset by error compensation. The error caused by thermal deformation.

(2) Built-in filtration and recirculating air conditioning system: During the dry cutting process, a large amount of fine dust particles are generated. These particles need to be discharged in time, and can be realized by a series of filter collecting systems; the machining area is an area prone to dust generation.
In this area, the spindle parts of the machine tool should be cleaned frequently to prevent excessive dust. In addition to the spindle components, the machine tool hydraulic and electronic control systems also need to be cleaned regularly to check for hidden dangers. Another method is to isolate the processing area from the machine tool, and at the same time effectively seal the machine parts, thus effectively preventing the intrusion of dust in the processing area; the circulating air conditioning system can use liquid nitrogen as a coolant, directly from the air. High purity nitrogen is separated and converted to liquid nitrogen for delivery to the cutting zone.

(3) Homogenization of equipment heating: the bearing area such as the front and rear bearings of the main shaft, the hydraulic oil pool, etc. are the main heating areas of the machine tool. In the design stage of the machine tool, it is necessary to consider the heating element away from the workpiece, so that the workpiece size that needs to ensure accuracy is avoided. To the influence of the heating element, if there are multiple heat sources, it is necessary to disperse these heat sources as much as possible to avoid concentration, and use a material with good thermal conductivity as a cooling component. In order to ensure the stability of the machine structure, some key components must use a high melting point metal material.

Of the two machine configurations shown in Figure 1, (a) is significantly better than (b). It can be seen from the figure that the positioning mounting surface H of the machine tool is a vertical surface. (a) The spindle head box of the structure only produces the displacement error in the up and down direction when working, and this direction is tangent to the surface of the workpiece. The sensitive direction; and (b) the construction of the headstock will produce a displacement in the Y direction. This displacement tends to be normal to the surface of the workpiece, which is a sensitive orientation and can have a large impact on the machining accuracy.

![Figure 1. Effect of machine structure on machining accuracy](image)

(4) Discharge of chips: As far as possible, the vertical spindle and the inclined bed are used, and the inclined spacers are added to facilitate the automatic chipping off; the inclined cover on the worktable is made of heat insulating material; the spiral chip flute is arranged, and a certain amount of chip evacuation space is reserved in the working area; in addition, a large amount of hot chips can be directly sent to the vacuum flute, jet or siphon system of the spiral flute, thereby effectively preventing the accumulation of hot chips on the workbench and the impact of other supporting components.

2.4. Dry processing cooling technology

(1) Liquid nitrogen cooling

There are two ways to cool liquid nitrogen, one is to spray directly on the surface of the machining tool or the surface of the workpiece being machined, and the other is to spray on the machining area. The main purpose of spraying on the surface of the tool is to cool the tool. In addition to the cooling purpose, the surface of the workpiece and the processing area have the effect of using low temperature liquid nitrogen on the material properties. The lower the temperature, the greater the brittleness of the material. The easier it is to process.

By comparing dry grinding, oil-cooled grinding and liquid nitrogen grinding, it can be found that the grinding temperature of liquid nitrogen grinding is significantly lower than that of dry grinding and oil cooling grinding. Needless to say, dry grinding does not have a good heat transfer carrier, and the
temperature will only increase as the grinding layer increases. Oil-cooled grinding is the most common process at present. With oil as the cooling medium, it only shows the characteristics of good heat transfer performance and good lubricating performance, and oil-cooled grinding is also prone to film boiling. However, liquid nitrogen cooling, in addition to the role of cooling and lubrication, also utilizes the physical properties of nitrogen. Nitrogen is an inert gas, which can effectively prevent the oxidation reaction from happening. The loss of the grinding tool is essentially the oxidation reaction of the tool sanding at high temperature. In addition to the loss of the tool, this oxidation reaction will also the surface quality of the workpiece has a certain influence. Therefore, reducing this oxidation reaction can improve the service life of the tool and improve the surface quality of the workpiece.

![Effect of different cooling media on grinding temperature](image)

**Figure 2.** Effect of different cooling media on grinding temperature

On the other hand, the method of nitrogen sparging is used to isolate the grinding area from the air, the abrasive grains cannot be oxidized, and the cutting performance is greatly improved. Low temperature grinding differs from dry grinding and oil cooling grinding. The grinding force of low temperature grinding increases slowly, while the grinding force of dry grinding and oil cooling grinding increases linearly with the increase of cutting depth. The trend, which results in the surface quality of the grinding is not up to standard, and the oil is cooled and ground, and the film boiling phenomenon is prone to deteriorate the processing conditions.

The inert liquid nitrogen cooling method is mainly applied to low temperature cutting of low temperature brittle materials and high temperature alloys, and is also applicable to the processing of some non-metal materials and composite materials. The use of liquid nitrogen as a cutting fluid has the advantage that other medium coolants cannot be compared: after the liquid nitrogen cutting fluid is used, the liquid nitrogen can be directly volatilized into the air to truly achieve a non-polluting green cutting and grinding process.

(2) Gas jet cooling

Gas jet cooling cutting technology is to pass a certain pressure of gas through a series of equipment, such as: safety valve, filter valve, etc., to flush the processing area by jet impact, to reduce the amount of lubricant under the premise of ensuring the cooling effect.

Jet impingement is a very effective heat transfer method that greatly increases the critical heat flux density and heat transfer coefficient. Gas jet cooling is generally the use of air and carbon dioxide as a medium source, the advantages of this medium source

Obviously, it is easy to extract and has no major damage to the environment.

Cold air cooling cutting is a kind of low temperature air used as a coolant and lubricant cutting process. It has been shown that this kind of low temperature cutting process has good surface roughness of the workpiece and less damage to the cutting tool. Carbon dioxide (CO2) can be used as a green cutting cooling lubricant. Carbon dioxide is the main culprit of the greenhouse effect. However, by observing the cutting process, it is found that the process itself does not emit carbon dioxide gas, and the carbon dioxide added to the lubricant is only a small proportion. Therefore, the environmental impact
is completely negligible. Figure 3 shows the effect of low temperature carbon dioxide on the temperature of the grinding zone.

![Figure 3. Effect of co2 cold air on the temperature of the grinding zone](image)

(3) Static cooling

Particles and electrons are carriers in a gas. Usually, there are very few carriers in the air. Under certain conditions, when a very weak electric field is applied to the air, a part of the carriers are attached to the electrode end. Neutralize. By gradually increasing the electric field strength, the number of carriers is increased, the energy generated by the neutralization reaction is gradually increased, the ionization process continues to progress, and the current in the gas is infinitely increased, and the air loses the insulating property and is broken down. Achieve cooling purposes.

The electrostatic cooling in dry cutting is actually through a series of cooling devices that blow the air that has been insulated through the above process into the cutting work area during cutting. The treated air will form an environment different from the surrounding area in the cutting area. This environment can not only reduce the temperature of the cutting area, but also form an oxide film between the tool and the workpiece. Lubrication.

(4) Internal cooling

Internal cooling technology is commonly used for dry grinding. In the grinding process, the grinding zone of the workpiece and the grinding tool is highly airtight, and the coolant that can enter the closed grinding zone is very small, and the heat exchanger is added by using a special material or a heat exchanger. The method can effectively reduce the grinding temperature of the closed grinding zone.

3. Summary

Green manufacturing is the effective use of raw materials, the optimization and adjustment of the manufacturing process, the precise control of product quality, and the integration of these factors with environmental protection in the manufacturing process of the product to achieve the optimal integration of economy and environment.

Therefore, this thesis has carried out research work on the machining technology technology for green manufacturing. The main research conclusions are as follows:

Suggestions and suggestions were given for the selection of machining tools in the green manufacturing process planning, and optimization measures for the use of cutting fluids were proposed to improve the function of the cutting fluid system.

The environmental impact process model of green manufacturing process elements is proposed, and the comprehensive evaluation score formula of green manufacturing process planning is introduced in the function solution.
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