Elementary Introduction of Alumina Ceramic Tool

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Abstract

The characteristics and properties of ceramic cutters are introduced in this paper,The types, development status, toughening methods and attentions of ceramic tool are introduced.

Keywords

Ceramic cutters; types; toughening.

1. Introduction

Ceramic is an inorganic nonmetallic material containing metal oxide. It has high hardness, good abrasion resistance, good chemical stability, low friction coefficient and high temperature performance.In modern cutting,Ceramic materials play an increasingly important role in cutting difficult to machine materials and high speed cutting fields due to their excellent chemical stability, wear resistance and heat resistance.The main raw materials Al2O3 and SiO2 are abundant in the crust, so their development and application prospects are very broad[1-4].In recent years,Manufacturing technology develops towards high precision, flexibility and environmental awareness,Under such circumstances, high speed cutting has become the mainstream of cutting.The development of high speed cutting mainly depends on the development of high speed cutting tools and high speed cutting machine tools.Among them, high speed cutting tool materials play a decisive role.Because ceramic tools can be cut at high temperature of 1200~1450, and can work under the cutting speed of 500~1000m/min, the development of ceramic cutting tools has become a hot topic in the research of cutting tool materials[5-6].

2. Properties of Ceramic Tool Materials

2.1 High Hardness and Wear Resistance

The hardness of the silicon nitride ceramic blade at room temperature has exceeded the hardness of the best cemented carbide blade to reach 92.5HRA ~ 94HRA, which greatly improves its cutting ability and wear resistance.Because of its high hardness, the wear resistance is greatly improved, and the durability of the tool is several times higher than that of the cemented carbide.

2.2 Good Heat Resistance and High Temperature Oxidation Resistance

Ceramic tools can still keep a certain degree of hardness and strength for a long time cutting at high temperature from 1200 to 1450 C. Therefore, the cutting speed which is far higher than that of hard alloy tools is allowed to achieve high speed cutting. The cutting speed is 3~10 times higher than that of the hard alloy tool, thus the production efficiency can be greatly improved.

2.3 High Red Rigidity

When the temperature of the cemented carbide tool is between 800 and 1000 degrees, the hardness will suddenly decrease.

2.4 There is a Minimal Affinity to the Metal

The Ceramic Cutters do not react with the steel at the melting temperature, and have good resistance to bonding, diffusion and oxidation wear. With a lower friction coefficient, the cutting force is reduced and the machined workpiece has a good surface roughness.[7]

3. The Types and Development Status of Alumina Ceramic Cutting Tools

There are many brands of ceramic cutting tools. According to their main components, there are two main categories: alumina (Al_2O_3) and silicon nitride (Si_3N_4). At present, 95% of the world's Ceramic Cutters belong to alumina (Al_2O_3) based ceramic cutters.

3.1 Pure Al2O3 Ceramic Cutting Tools

the content of Al_2O_3 in the material is more than 99%, by adding a small amount of burning aid (such as MgO, NiO, Cr_2O_3, TiO_2 and so on), it is made by pressure sintering. The pure Al_2O_3 ceramics have low bending strength, poor impact resistance, and the cutting edge is easy to collapse, but the high temperature performance is very good. It is suitable for small feed semi finishing cast iron and steel.

3.2 Al2O3 Carbide Ceramic Cutting Tools

the addition of certain carbides (TiC, WC, MO_2C, Cr_3C_2) in Al_2O_3 can improve the strength and impact resistance of the ceramics. It is suitable for high speed rough machining, wear-resistant cast iron, hardened steel and high strength steel. Compared with pure Al_2O_3 ceramics, the bending strength of Al_2O_3 TiC ceramics is higher than that of pure Al_2O_3 ceramics at both normal temperature and high temperature, and the decrease rate is slower at high temperature (above 1000 degrees C).

3.3 Al_2O_3 Ceramic Cutters with Nitrogen Compounds and Borides are Added

Al_2O_3 nitride composite ceramic cutters with nitrogen compounds in Al_2O_3 have good thermal shock resistance. Their basic properties and processing range are equivalent to Al_2O_3 carbide cermet cutting tools, which are more suitable for intermittent cutting, but their bending strength and hardness are compared to Al_2O_3 Ti C Metal ceramic cutters are low. Ti B2 is used as binder for ceramic cutting tools in Al_2O_3. It has excellent impact resistance and wear resistance.

3.4 Toughened Al_2O_3 Ceramic Tool

toughened ceramic Al_2O_3 means adding toughening or reinforcing material in Al_2O_3 matrix[8].

4. Common Toughening Methods for Alumina Based Structural Ceramics

4.1 Whisker and Fiber Toughening

Toughening of whiskers and fibers is an important means to obtain high toughness ceramic materials. Whisker or fiber toughening means using whiskers or fibers as reinforcements, and combining them with Al2O3 matrix through a certain combination process to make composite materials. Commonly used whiskers or fibers include carbon fibers, SIC whiskers, B fibers, etc. When selecting whiskers or fibers, we should pay attention to the matching of Al_2O_3ceramic properties. The thermal expansion coefficient of whiskers or fibers should be slightly larger than that of Al_2O_3 matrix, which should have the same high temperature resistance as Al_2O_3. At the same time, the whisker or fiber should be treated to improve the compatibility, stability and bonding strength of the whisker or fiber.

4.2 ZrO_2 Phase Transition Toughening

There are many materials for toughening Al_2O_3 ceramics. At present, toughening of Al_2O_3 based ceramics by ZrO_2 is the most effective. ZrO_2 has the best thermal stability and heat insulation at high temperature. Its thermal conductivity is the lowest among common ceramic materials, and its thermal expansion coefficient is close to that of metallic materials. In recent years, composite ceramics with ZrO_2 as toughening agents have developed rapidly.

4.3 Toughening of Particles

The addition of metal particles in Al_2O_3 ceramics can significantly improve the fracture toughness. The toughening effect is achieved through the bridging and plastic deformation of metal particles, but the toughening method will make the electrical insulation and chemical stability of the material worse. The development of nanotechnology provides a new way for the study of grain toughening of precision structural ceramics[9].

5. Matters of Attention in the Application of Ceramic Cutting Tools

The Machined Machine Must Have Good Rigidity, Sufficient Power And High Revolutions

The better the quality of the blank, the better the processing effect. Although ceramic tools can rough rough blank, it is not that the worse the blank is, the better.

The Cutting Speed has a Great Influence on the Cutting Condition. the Blade with Different Groove and Slot Width Can Only Get Satisfactory Chip Breaking Effect if the Cutter Angle and Cutting Amount are Matched

The cutter is translocated at the right time. When the lathe tool is worn to a certain extent, the blade translocation angle or the new blade should be replaced in time [10].

6. Conclusion

Ceramic tool materials have unparalleled advantages over other materials. Aiming at different workpieces and processing conditions, cutting tool material serialization and standardization is an effective way to make ceramic tool materials widely used. With the development of science and technology and the enhancement of people's awareness of environmental protection, high speed cutting and dry cutting will become the mainstream of cutting and machining, and the ideal high speed cutting and dry cutting tools of ceramic cutters will bring a remarkable innovation for the machinery processing industry [11].

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