

# Research on Precision and Ultra-precision Machining Technology Development

Zhenghong Zhu, Qian Jiang

School of Mechanical & Vehicle Engineering, Hefei University, Anhui, China

891776413@qq.com

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**Abstract.** This paper based on the analysis of precision and ultra-precision machining of the status quo, research on its development of new materials, new technology, machine tools and other aspects. Put forward that China should take a few basic measures, think about the future development of the field.

## Introduction

Our country is the big manufacturing country in the world, living in the world's fourth manufacturing output, even though it can produce some precision products, most of the core components rely on imports, such as aircraft, automobile engines, high-end CNC machine tools. Precision and ultra-precision machining apply in the field of aviation, aerospace and defense that is particularly important.

The concept of precision and ultra-precision machining has a variety of claims, because the precision and ultra-precision machining is using the latest technological achievements to improve the processing level, so its concept is evolving. The current ultra-precision machining is without changing the physical properties of the material, as much as possible to achieve the ultimate precision. The precision higher than  $0.1\mu\text{m}$  surface roughness Ra value of less than  $0.1\mu\text{m}$  processing method which called ultra-precision machining.

Factors affecting the processing precise is mainly aspects precision machine tools, precision machining environment, precision machining tools, processed materials, precision measurement. Most scholars from various countries research on it around the several aspects. This paper induction and study on the latest development aspects of precision and ultra-precision machining.

## Technologic Advances

The development of precision and ultra-precision machining technology directly affects the development of cutting-edge technology and a national defense industry, the world of this extremely seriously, vigorously carry out research and development investment. For the importance of energy and space development, the United States for decades invested heavily in large ultraviolet, X-ray detection of large-diameter telescope mirrors processing research, in order to promote space development program. In the 1970s, Japan established the ultra-precision machining technology committee and developed a corresponding development plan, the technology in the high-tech industry, after years of development, the Japanese civilian optics, electronics and information products industry is the leader of the world. CUPE is one of Britain's precision engineering research center in the world today, it is a unique representative of the British ultra-precision machining technology level. After 1992, Europe has implemented a series of joint research and development program to strengthen and promote the development of precision ultra-precision machining technology.

China put forward the concept of a real system of ultra-precision machining technology is 80 to 90 years of the 20th century. At that time, ultra-precision machining technology is military technology, in terms of equipment or process, the implementation of the technology blockade abroad, so the study of domestic precision machining technology is basically the start of the study

from the precision machining equipment. Appeared in the mid-precision and ultra-precision machine tools as well as a world-class level of technology appropriate 1980s. Especially in the late 1990s, a number of units have been successfully developed a non-spherical ultra-precision machining equipment, which marks the level of ultra-precision machining equipment in our country to a new level.

### **Development of Precision and Ultra-precision Machining in New Materials, New Technology Areas**

To meet the high-precision, high reliability, high stability, quality demand, many metals and alloys, ceramics, optical glass, etc. need to go through ultra-precision machining to achieve the specific shape, accuracy and surface integrity. Advanced ceramic materials has become a high-precision machinery, one of the foundations of aerospace, military, optical information development. Structural ceramics have excellent high temperature wear resistance, Swedish University of the West developed a coating material to enable high temperature aircraft engines the duration was extended to three times the original, metal layer to protect the engine is not broken and irregular plane to improve its adhesion. France, the United States, Germany, an international research team synthesized the high quality graphene nanoribbons, at room temperature, to verify its good electrical conductivity, for the development of new electronic devices to expand the space. Qingdao University of Science and Technology of China's self-developed training RT-rubber antioxidant 4020 and Secretary of the production of new technology breakthroughs, breaking a new international blockade of rubber antioxidant production technology, greatly improving China's international status.

High-speed machining technology is the most basic metalworking and most reliable means of precision machining. In recent years, the international academic Production Engineering Research Association annual meeting are "ultra high-speed cutting" as the theme. After decades of breakthroughs in key technology areas such as machine tools and equipment, high-speed cutting technology matures, high-speed machining technology has entered the stage of industrial applications from theory. US Aerostell series, maximum speed up to 41000r/min, maximum metal removal rate per minute 3500cm<sup>3</sup>/min, the tool is widely used in large-scale processing of aluminum aerospace components. Germany Fette plant, Pfauter-Magg, Italy and the United States Star SU plant launched multi-slot, instead of the traditional long TIN coating hob with circular grinding method improves the precision gear cutting tool life and cutting speed and roll tooth efficiency. Our high-speed machining technology in the late 1980s and started cutting mechanism most research areas, such as Shandong University research group combines cutting tool material Ceramic, concerning the establishment of a model of cutting force and cutting temperature, tool wear and breakage theory. High-speed cutting is a new method of metal cutting, which has high precision machining dimensions, low surface roughness characteristics. Such as high-speed milling surface roughness can reach ground level. This processing of high hardness, high strength, poor thermal conductivity metal materials provide a solution, which also a better way to low hardness and high plastic material processing. With the development of aerospace, precision ultra-precision machining technology faces many new challenges. For example: Now titanium, aircraft engines leaf disc blade parts machining difficult materials and the overall structure of large aircraft, high-strength thin-walled complex shaped parts and precision abrasive surface, low damage surface machining precision ultra-precision machining, etc. are urgently needed breakthrough technologies. Therefore, the research of precision and ultra-precision machining in the new materials, new technology without delay.

### **Precision and Ultra-precision Machine Tools Development**

United States and Europe carry out the first national study of precision machine tools. In the late 1950s, due to the development of aerospace and other cutting-edge technology, the United States developed the first ultra-precision diamond cutting tool technology, called "SPDT technology", and the corresponding air bearing ultra-precision machine tool spindle for machining laser fusion mirrors, tactical missiles and manned spacecraft with large spherical aspheric parts. At least for now the United States has more than 30 companies to develop and produce various kinds

of ultra-precision machine tools, such as the Lawrence Livermore National Laboratory, Moore companies. Britain's institute of Precision Engineering which called Cranfield, production of nano machining center can perform ultra-precision turning, but also with a grinding, but also for ultra-precision grinding. German company JUNG said the series of machine for the first time with a gantry frame structure, to meet the large size of the workpiece, and a new project grinding material needs. Switzerland MIKROM's high-speed precision five-axis machining center, the maximum spindle speed of 42 000 r/min, the positioning accuracy of 5 $\mu$ m, has reached the last coordinate precision boring machine. Precision and ultra-precision machine tools to achieve precision and ultra-precision machining of the basic conditions, with the improvement of the means test, the machine from the traditional static stiffness increased to dynamic stiffness and thermal stiffness requirements. Beijing Research Institute of China's machine tool is one of the main unit of the domestic precision machining technology research. 2002 as a unit of the military developed the "SPHER200C spherical ultra-precision machine tools." Harbin Institute of Technology successfully developed HCM-1 sub-micron ultra-precision machine tools.

In recent years, the aerospace, medical, communications, electronics and other civilian consumer market, a large number of micro and small machinery products have been developed using, greatly improve the quality of life. While micro product has been extensively studied in the field of aerospace, defense and science and technology and use, and has made a series of achievements. Micro precision parts machining, typically using conventional precision and ultra-precision machining equipment, but for some small features difficult to accomplish even the part can not be processed, the current commercial single micro-machining methods. Micro and small parts used in different processing method for processing a variety of microcomputers in bed, repeat setup process will change the base, resulting in significantly reduced machining accuracy. If you can make a fixture, a unified processing base, complete a variety of processing, which will greatly improve the precision of parts on the same equipment. To solve this processing problems, improve the manufacturing level of micro-manufacturing industry, the development of a complex precision micro-machining system is imperative.

### **Ultra-precision Machining Precision Development Trends**

Presently, Precision and Ultra-precision Machining still has great development space on machining accuracy. A processing method is presented, which can remove atomic unit. In America's national research project, the research material of Ultra Precision Machining Technology has been extended from traditional material such as aluminum and copper to hard cutting material and hard brittle nonmetal material and processing method has been extended from cutting to Ultra Precision Technology with feedback and coating process of the final surface. In the early 1980s, Japan has proposed ultra-precision machining development program which established two main development directions. One direction is high density and high performance particle beam processing, the other is high performance ultra-precision machining technology which mainly processes 3D curved surface and 3D ultra-precision detection technology. According to the development trend of foreign precision machining and the actual situation of our country, we should carry out fundamental research of ultra-precision machining technology which includes ultra-precision machining method of removing minimum unit, development of precision mechanical mechanism, high precision test system and new material which is suitable for ultra-precision machining and obtains high precision and high surface quality.

### **Conclusion**

Although our country has made some progress in the ultra-precision machining field, even reaching the world's advanced level in some ways, there is a considerable gap in terms of depth and breadth of research work, and engineering and commercialization of research results, compared with the advanced world level generally. Firstly, basic theory and experiments of ultra-precision machining technology need further development, for example molecular dynamics simulation is

applied to research of nanometric cutting and grinding process. Then processed materials and processing methods should be extended constantly. Finally, the original purpose of ultra-precision machining technology guarantees the final accuracy of some key parts

Our country has put the "high-end CNC machine tools and basic manufacturing equipment" as one of the major projects of science and technology which are confirmed by "national medium and long-term science and technology development plan". The objective of the major project is that our country will possess the ability to develop independently major products of high-end CNC machine tools and basic manufacturing equipment, the overall technical level reaches the international advanced level and some products lead the world, a complete system of functional unit development and supporting is established, technology innovation system in which enterprises is the main body and enterprises, universities and research institutes are integrated is formed, a high-quality research and development team is established, 80% high-end CNC machine tools and basic manufacturing equipment required by Aerospace, shipbuilding, automobile, power generation equipment manufacturing are produced by our country.

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