The Japan Society for Precision Engineering

Introduction of JSPE Technology Awards for 2006

1. Development of Elliptical Vibration Cutting Device for Superprecision Machining and Microfabrication of High Hardness Material

Seiji HAMADA, Takashi UEYAMA (Taga Electric Co., Ltd.), Norikazu SUZUKI, Eiji SHAMOTO (Nagoya Univ.)

The Elliptical Vibration Cutting Theory developed by Toshimichi Moriwaki and Eiji Shamoto has attracted attention as a big step toward next-generation superprecision microfabrication. The innovative aspect of this theory drastically changed the concept of vibration cutting. Based on this theory, the cutting debris is compulsorily dragged by the tool tip that vibrates ecliptically and moves in the direction of cutting debris outflow, resulting in a remarkable decrease in cutting resistance. Cutting processing of highly-fragile material also becomes possible. Additionally, the theory enables superprecision cutting processing of hardened steels with a diamond tool, which in the past was said to be impossible. It is an epoch-making technology that opens the way to new processing fields.

We have developed an excellent, practical superprecision processing ultrasonic elliptical vibration cutting device that can endure use in the general superprecision microfabrication industry. Even a worker who is not accustomed to handling the ultrasonic can easily operate the developed EL-50Σ. The oscillator can generate an elliptical vibration of 4μm diameter at 39.5kHz. Also, the device was confirmed to exhibit an amplitude fluctuation of 3nm or less, and to be able to continue steady processing even in 3 days' uninterrupted operation. Monocrystalline diamond bites have been installed, as shown in Fig. 1, and a variety of superprecision processing tests were performed.

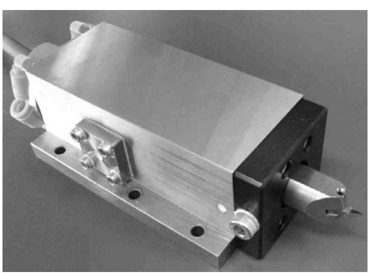

Fig. 1 Elliptical oscillator equipped with monocrystalline diamond

The superprecision processing of tungsten alloy and hardened steel is already practical for production and processed surface roughness of 5nm Ra or less has been confirmed. Moreover, superprecision cutting of very fragile materials such as glass, lithium niobate, and calcium fluorides in the ductile mode is possible by ecliptic vibration cutting. Its practical applications are expected by future improvements.

2. Development and Practical Application of MQCJ-Lubricated Angular Contact Ball Bearings for Machine Tool Main Spindles

Masatsugu MORI, Yoshinobu AKAMATSU, Mineo KOYAMA, Futoshi KOSUGI, Hiroshi TAKIUCHI, and Takuji KOBAYASHI (NTN Corporation)

Bearings for machine tool main spindles have been required to operate at higher speeds, in order to improve surface quality of the machined piece and to boost machining efficiency. Recently, lower bearing power loss is also needed, in order to reduce environmental burden.

The developed bearings are equipped with a new lubrication system "Minimum Quantity and Cooling Jet", abbreviated "MQCJ," to realize benefits obtained from both the conventional oil jet lubrication and air-oil lubrication methods.

The oil jet lubrication method involves considerable power loss due to the agitation resistance of large quantities of lubricating oil, while showing excellent capability of cooling the bearing for higher speed rotation.

The air-oil lubrication method, on the other hand, is much lower in power consumption, but is not appropriate for high-speed operation, due to a lack of cooling capability.

The new MQCJ system solved this trade-off problem between the above two lubrication methods. Figure 2 illustrates the structure that realizes this ideal lubrication mechanism. A small portion of the injected oil passes through the clearance between the inner ring and the spacer to reach and lubricate the internal structure of the bearing, while the remaining larger portion of the lubricant cools the inner ring and is then discharged.

The MQCJ prototype angular contact ball bearings successfully demonstrated the world's fastest speed of $d_m n$ 5 million under constant-pressure preloading and a speed of $d_m n$ 3.6 million under definite-position preloading.

The MQCJ-lubricated bearings are expected to make a significant contribution to development of faster machine tools with lower power loss.

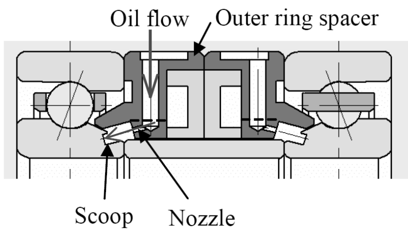

Fig. 2 Bearing system structure

3. Development of High-Acceleration and Ultra-precision Linear Motor Drive Machine Tool AZ150 Equipped with Anti-Vibration System

Kazuo NAKAMOTO, Shinichi MATSUMOTO (Sodick Co., Ltd.), Masahiro ANZAI (RIKEN)

With the spread of mobile phones and increasing trends towards low energy consumption, components are becoming smaller and lighter, leading to growing demands for molds used for the mass production of such components. This report describes the development of a high precision, highly efficient machine tool to meet such needs.

To enhance dynamic precision, a ceramic, lightweight moving body and high-response linear motor were adopted. Machining time is known to depend considerably on the acceleration rate in the machining of micro shapes. Generally, acceleration during machining on a general machine tool ranges from 0.01G to 0.1G. This machine tool was designed so that all machining steps can be performed at 0.5G. In addition, to resolve the problem of self-vibration which occurs at high acceleration rates, an anti-vibration mechanism was mounted in this machine tool. This mechanism moves objects of the same weight in opposite directions to prevent changes in the position of the center of gravity and cancels counteraction, thereby sharply reducing vibration. Figure 3 shows the X-axis anti-vibration mechanism.

The main spindle was designed for a speed of 120,000 min^{-1} for use with small-diameter tools. Air static pressure bearings are used to realize high rotational accuracy. An air turbine drive was also adopted to realize saturation of thermal displacement in a short time, as well as long-term stability.

For the truing system, the thermal insert method was chosen by virtue of its simple mechanism, stable grip force even in ultra-high speed rotation, and high repetitive accuracy. The thermal insert holder is fixed to the main spindle rotor and cannot be removed. The high-frequency induction method is used for heating. Use of these mechanisms has successfully realized a means of machining micro shape molds with high precision and efficiency.

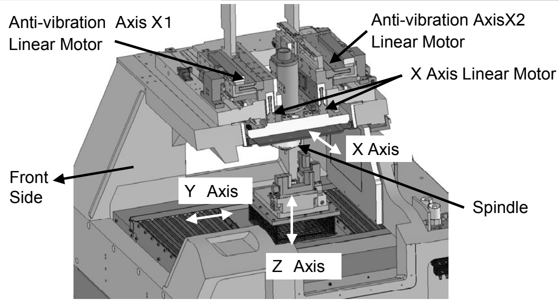

Fig. 3 Axis anti-vibration mechanism

Introduction of The 28th Machine Tool Engineering Foundation Award

[PAPER AWARD 2006]

1. Study on high efficiency machining with reaction-free Shuttle Unit

Kenzo EBIHARA, Akira YAMAMOTO, Tomohiko KAWAI, Yoshimi TAKEUCHI

J. JSPE, Vol. 73, No. 2

2. General Tool Setting Error Compensation Method for 5-axis Control Ultraprecision Machining

Makoto SONO, Tohru ISHIDA, Koji TERAMOTO, Toshiyuki ENOMOTO, Yoshimi TAKEUCHI

J. JSPE, Vol. 73, No. 10

3. Development of milling-combined laser metal sintering method -Combination of laser-assisted metal sintering method and the milling in one machine-

Satoshi ABE, Yoshikazu HIGASHI, Hirohiko TOGEYAMA, Isao FUWA, Norio YOSHIDA

J. JSPE, Vol. 73, No. 8

4. Study on 5-Axis Dry EDM

Masanori KUNIEDA, Shintaro NAKANO, Ichiro ARAIE

J. JSPE, Vol. 73, No. 8

Introduction of FANUC FA and Robot Foundation

[PAPER AWARD]

1. Dynamic Behavior of Feed Drive Systems around Quadrant Changes in Circular Motion

Ryuta SATO, Masaomi TSUTSUMI, Kazuo NAGASHIMA

J. JSPE, Vol. 72, No. 2

2. A Study on Magnetic Bearing Spindle for achieving a High DN Value -A Proposal of Bearing Structure for High Stiffness and Low Eddy Current Loss-

Teruo MARUYAMA, Tohru NAKAGAWA, Isao TASHIRO

J. JSPE, Vol. 72, No. 8