The Japan Society for Precision Engineering

Introduction of JSPE Young Researcher Awards 2011

1. Masahiro UEDA

Influence of Ball Behavior in Ball Screws on Lost Motion (3rd Report)

− Determination of Ball Wedging and Lost Motion in Ball Screws−

J. JSPE, Vol.77, No.2, pp.186-193

Even if the ball screw is preloaded with a double nut in order to eliminate backlash between the screw shaft and the nut, linear actuators driven by ball screw mechanisms generate non-linear relationships between the linear motion of the nut and the rotary motion of the screw shaft when the ball screw drive is reversed. The behavior of the ball screw mechanism, which is referred to as lost motion, can contribute to positioning errors of linear actuators.

The present paper describes a method by which to calculate the axial stiffness of a ball screw with ball wedging and to determine the lost motion when the ball screw drive is reversed. An attempt is made to evaluate the ball wedging and the lost motion in a preloaded ball screw with a double nut by a comparative study of analytical and experimental results. The lost motion is determined to be produced primarily by the ball wedging. In addition, the effects of internal geometry in the ball screw on the lost motion generated by the ball wedging are analytical investigated based of the calculated results.

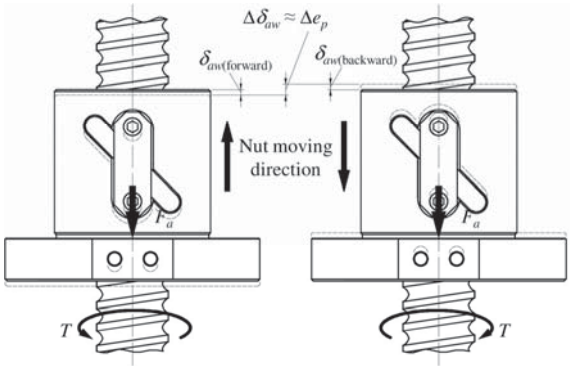

Fig. 1 Determination of lost motion

2. Yui SUDO

Development of Chatter Vibration Detection utilizing Disturbance Observer (1st Report)

− Precise Sensor-less Process Monitoring utilizing Average T method−

J. JSPE, Vol.77, No.7, pp.707-712

This paper presents a sensor-less process monitoring method to detect chatter vibration in square end milling. The method of monitoring cutting forces and detecting chatter vibration using external sensors such as accelerometer and force sensor has been proposed. However, using external sensors increases the cost of manufacturing systems and additional structures for sensor implementation often decrease the stiffness of workpiece fixturing, and it results in another chatter vibration. Therefore, a novel method without using any external sensors is developed to detect high-frequency vibration. Concretely, disturbance torque acting on the spindle is estimated by using disturbance observer and used simultaneously for spectrum analysis. From the experimental results, it is confirmed that the proposed method enables to estimate high-frequency disturbance. Certain peaks which are considered as a peak frequency of chatter vibration can be detected.

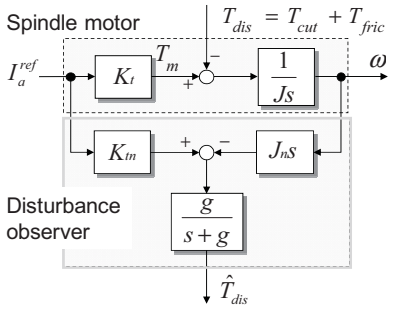

Fig. 2 Disturbance observer

3. Yuji OGAWA

Development of a Nondeforming Freezing Pin Chuck (1st Report)

− Design of a Freezing Pin Chuck Based on Freezing Liquid Characteristics−

J. JSPE, Vol.77, No.8, pp.771-775

Polishing is commonly used to attain high flatness and smoothness for silicon wafers and rectangular glasses. A flatness of better than 10 μm is required for large quartz masks to transfer fine patterns. A backing pad is usually used to hold the workpiece during one-sided polishing. However, it is difficult to fabricate a nonwarped mask by this method. Therefore, a nondeforming freezing pin chuck has been developed. This paper describes the principles of the nondeforming chuck and the process used to manufacture a nonwarped substrate. The temperature distribution in the chuck, the droplet profile and the shear peeling strength of the freezing liquid are investigated. The temperature distribution of the freezing pin chuck is calculated by the finite element method using an axisymmetric model. The results reveal that, for a polishing temperature of less than 30°C, use of a coolant at 5°C with a heat transfer coefficient of 1000 W/(m^2·K) can reduce the temperature on the back surface of a quartz substrate to below 15°C for a substrate that is over 2 mm thick. The freezing liquid has a contact angle from 20° to 40°, which is much smaller than that of water. Consequently, the pin must have a diameter of over 0.73 mm. The average shear peeling strength of the freezing liquid is improved from 37 to 80 kPa by lapping the pin top. Based on these results, a freezing pin chuck with a pitch of 2 mm and a pin diameter of 0.8 mm was designed for polishing applications.

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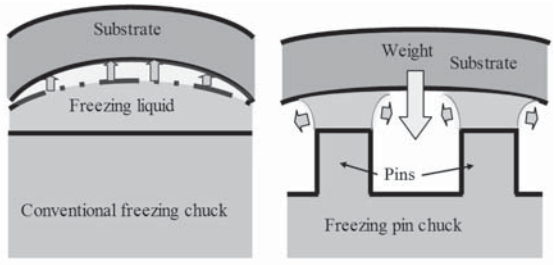

Fig. 3 Principle of nondeforming chucking

4. Cefu HONG

Influence of position-dependent geometric errors of rotary axes on a machining test of cone frustum by five-axis machine tools

Precision Engineering, Vol.35, No.1, pp.1–11

A machining test of cone frustum, described in NAS (National Aerospace Standard) 979, is widely accepted by machine tool builders to evaluate the machining performance of five-axis machine tools. This paper discusses the influence of various error motions of rotary axes on a five-axis machine tool on the machining geometric accuracy of cone frustum machined by this test. Position-independent geometric errors, or location errors, associated with rotary axes, such as the squareness error of a rotary axis and a linear axis, can be seen as the most fundamental errors in five-axis kinematics. More complex errors, such as the deformation caused by the gravity, the pure radial error motion of a rotary axis, the angular positioning error of a rotary axis, can be modeled as position-dependent geometric errors of a rotary axis. This paper first describes a kinematic model of a five-axis machine tool under position-independent and position-dependent geometric errors associated with rotary axes. The influence of each error on machining geometric accuracy of a cone frustum is simulated by using this model. From these simulations, we show that some critical errors associated with a rotary axis impose no or negligibly small effect on the machining error. An experimental case study is presented to demonstrate the application of R-test to measure the enlargement of a periodic radial error motion of C-axis with B-axis rotation, which is shown by present numerical simulations to be among potentially critical error factors for cone frustum machining test.

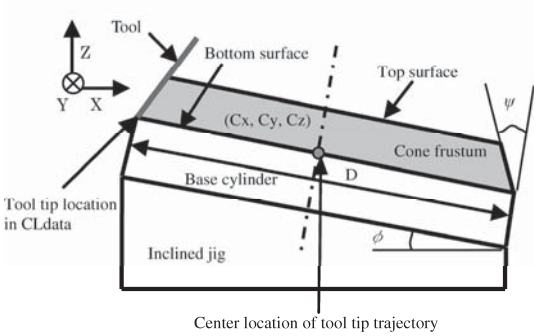

Fig. 4 Setup for machining test of cone frustum

Introduction of JSPE Takagi Awards 2011

1. A Conceptual Design Method of Disc Brake Systems for Reducing Brake Squeal Considering Pressure Distribution Variations

Toru MATSUSHIMA, Kazuhiro IZUI and Shinji NISHIWAKI (TOYOTA MOTOR CORPORATION)

J. JSPE, Vol.77, No.5, pp.525-532

This paper proposes a design optimization method for disc brake systems that specifically aims to reduce brake squeal, with robustness against changes on contact surface pressure distribution, based on the concept of First Order Analysis. First, a simplified analysis model is constructed in which a pressure distribution parameter is introduced, and the relationships between the occurrence of brake squeal and the characteristics of various components is then clarified, using the simplified model. Next, a new design performance measure that takes pressure distribution changes over the contact surfaces into account is proposed for evaluating brake squeal performance, and an optimization problem is formulated in which this performance measure is used as a constraint condition, with maximization of the brake-pad contact area as the objective function. The optimization problem is solved using a genetic algorithm. The proposed method is then applied to design problems and a disc brake system is constructed based on an optimal solution. Finally, experimental studies are conducted to confirm that the proposed method can yield optimal designs that minimize brake squeal and are robust against pressure distribution changes.

2. Study on Detection Technique for Bubbles in a Piezo-Driven Inkjet Head

Tsuyoshi SATO, Katsuyuki SOEDA and Toshiro HIGUCHI (TOSHIBA CORPORATION)

J. JSPE, Vol.77, No.9, pp.861-867

The stability of jetting is a major requirement for industrial inkjet heads. Air bubbles entrapped in a piezo-driven inkjet head can occasionally cause jetting failures. The piezo actuators can be used as sensors to detect the acoustic influence caused by air bubbles. As in our previous paper, we developed a controllable bubble generation method by focused THG Nd:YVO4 laser with the secondary Bjerknes forces and could intentionally generate bubbles from about 5 micron to 150 micron in radius at the designated point near the nozzle inside the inkjet heads.

In this paper, experimental results on the relationship between the electric signal from the piezo actuators and bubbles are presented. We find the existence of a kind of a dead zone where the emitted sound pressure from a bubble is insensitive to the bubble size. Our numerical study shows this phenomenon is attributed to the increase of the radiation impedance with an increasing bubble size in reverberant sound fields as in the inkjet heads. We also present CFD simulation results using models with a bubble inside an inkjet head in order to make an estimate of the bubble size and position to cause jetting failures.