Overview on the ASPE annual meeting of 1990, Rochester, N.Y.

OVERVIEW ON THE ASPE ANNUAL MEETING OF 1990 ROCHESTER, N.Y.

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1. INTRODUCTION

I got a chance to join the Annual Meeting of 1990 to present a poster called "Stiffness characteristics of externally pressurized gas bearings", written by me and dr. ir. P. H. J. Schellekens. The Meeting of this year is the Fifth Annual Meeting of American Society of Precision Engineering (ASPE) which was founded in 1986. ASPE is an international, multidisplinary professional and technical society concerning research and development, design, manufacture and measurement of high accuracy components and systems. ASPE annual Meeting is the international forum for the exchange of ideas, for the discussions of the solutions to problems, and for the presentation of results involving precision engineering.

The meeting presents the following characteristics: 1). dynamic view on the precision engineering, e. g. random organization of technical session; 2). more interactions between the research and commercial organization, e. g. massive participation of commercial session and the exhibitions, from 3 people last year to more 200 this year; 3). expanding the activity in universities, three were short presentations on the research and education activities in the universities (three of them are newly established).

2. BASIC SCOPE OF PRECISION ENGINEERING

The arrangements of tutorial and selection of papers could present the basic scope of precision engineering which the ASPE defined. There were 17 tutorials in the this year Annual Meeting. It covers four disciplines: 1). Metrology (6); 2). design concept (include environmental controls) (6); 3). control (3); 4). manufacturing process (3). The titles of tutorials are listed below:

Metrology: 1). Dimensioning and tolerancing to ANSI-Y14.5
2). Basic machine tool metrology
3). Surface metrology
4). Interferometric metrology
5). Axis of rotation metrology
6). Distance measuring interferometry

Precision Design

1). Precision machine design
2). Patterns for precision instrument/machine design (mechanical aspects)
3). Materials for precision engineering
4). Analyzing the dynamic performance of high precision machines
5). Applied vibration isolation
6). Temperature control

Control theory

1). Control of precision mechanical system
2). Computer system for precision engineering application
3). Application of basic control theory

Manufacturing process

1). Basic diamond turning techniques
2). Classical grinding and polishing techniques
3). principle of grinding

I participated three of them: 1).Patterns of precision instrument design (mechanical aspects) by Clayton Teague and Chris Evans; 2). Basic machine tool metrology by Robert Hocken; 3). Control of precision mechanical system by Thomas Dow.

The tutorial given by C. Teague and C. Evans presents the basic concepts for precision design. According their experiences and studies, twelve basic patterns are summarized, i.e.

* repeatability	* isolation	* kinematic mounting
* alignment principle	* metrology frame	* material selection
* structural loop	* kinematic drive	* probe knowledge
* energy flow	* error budget	* symmetry

Nearly all the concepts have been defined in the Metrology Laboratory, TUE, in the more or less similar way, to my knowledge. This is not the coincidence. It is because "metrologist knows what is wrong with the instrument/machine when they try to measure high accurate components or systems using that instrument or machine" (C. Teague).

The tutorial by R. Hocken gives the basic contains of the Draft American standard of Machine center ASME B5.52 version 6.0, 1990 and similar parts of the American Standard for Coordinate Measuring Machines B89.1.12.-1990. He put these two together because machine tools in the non-cutting stage are similar as measuring machines. The measuring sequence are suggested: Drift-relative vibration-hysteresis-rigid body-parametric(linear-rotation-multi-axis-instrumentation). The hysteresis and rigid body tests are emphasized.

The tutorial by T. Dow gives basic concepts of the control of mechanical systems. One nice thing is that the open loop control with the inverse transfer function of the real system as controller to eliminate the following errors which will present significant error in the shape generation in a cutting process.

The papers presented in the Meeting can be summarized in the following categories:

Nanotechnology: the topics includes:

1). New developments:

a). head scanning fiber optic interferometer STM with high resolution images.
b). sub-angstrom resolution 3D, laser interference microscope by using computerized phase measurement interferometry.
c). photon STM with $\lambda/20$ lateral and $\lambda/100$ vertical resolutions which senses the exponentially decaying evanescent field above a dielectric in which total internal reflection is made to occur.
d). STM bit-making for high density memory chip. With 5 nm hole-hill structures acting memory bits, one could place on

gigabyte of information on a one square millimeter surface.

c). The atomistic computer simulations of orthogonal cutting process with 5 nm depth provides more information on the energy flow, material flow, and plastic deformation.

2). micro-dynamics:

It shows that the rolling guideway has linear relationship between the force and displacement. By using this micro-dynamics principle, "a nanometer positioning of better than 1 nm resolution, 200 mm/s maximum velocity and 250 mm stroke is achieved." The nanometer control is also carried out for the digital interferometer to control precise position of grating carriage.

3). Micro-mechanism:

The silicon provide possibility to manufacture micro-mechanisms by lithography technology which may be used for "nano-machines".

Metrology:

1). Surface metrology

The step measurements haven performed in NIST by using the phase-shifting interference microscope, mechanical stylus instrument and multiple-beam interferometry. At present, the obtained step height uncertainty ranges from 1 nm for 30 nm to 7nm for 3000 nm.

The comparison of the roughness measurements by mechanical and optical means are also reported. The rms surface slope and the angular spread of light scattered from a rough machined surface are used to evaluate the surface roughness. The conclusion is that there are definite relation between these two parameters independent on the materials.

The recent progress in the surface metrology shows that the state space methods provide useful additional techniques in

analysis of surface topography. The useful information about the dynamics of machining process can be extracted from a measured surface.

The experiments on the optical differential interference surface profiler shows that a deviation from square step sample make the frequency response function appear to roll off more rapidly than it actually does. "The accurate representation of surface heights containing high high frequency structures oversampling is desirable."

2).Error modeling and correction of a laser traker:

It point out that the extreme care must be taken in removing the systematic errors. the beam bending needs to be compensated in real time.

3). Probe system:

Air bearing has been used in the ultra precision stylus profilometery for lager optical components. High precision probe is a small precision machines. All the concepts developed in precision machine design are used to develop this special probe system.

4).new sampling techniques and algorithms for CMM's:

It is concluded that if measurements of high-accuracy are required, a lager number of points will have to be sampled than is customary.

5). absolute rafractometer:

By combining two refrectometers, an absolute rafractometer was presented.

6). temperature enclosure:

The temperature control is an important topic nowadays, the commercialization of temperature enclosure was developed by using plastic materials.

4). LDDM:

Based on the current development in laser radar technology, Laser Doppler Displacement Meter has been developed. The linear resolution is 0.025 μm and angular resolution is 0.2 arc sec.

X-ray and optical design:

1). Lithography:

The industrialized technology of stepper lens today is only suitable for production of 16 Mb DRAM. The further improvements suitable for 64 Mb DRAM production are expected through exploration of more aggressive refractive lenses operating at deep-UV wavelength with laser sources". To fabricate reflective diffraction limited lenses operating in the soft X-ray region printing 0.1 μm circuit patterns over large areas will be possible in the next decade with progress in precision engineering. The past few years have been witness to significant advances in the development of normal incidence x-ray mirrors and beam splitters, diffraction limited x-ray lenses, and CCD x-ray detector arrays. Utilizing these new capabilities, we are taking the first steps toward the development of sophisticated x-ray optical systems including soft x-ray interferometer, high intensity x-ray lasers, and projection optics for x-ray lithography.

2). Astrophysics:

The advanced x-ray astrophysics facility has been under way for over a decade which is now scheduled for shuttle launch in 1997. The major challenge to the precision engineering community is that a 12 element nested Zerodur mirror with a maximum diameter of 1.2 meters and inner grazing incidence angle of 0.5 degrees or less is required. The special metrology techniques are also

developed for measuring inner diameter and circumstantial length.

3). Optical design:

By using the mask as a reflection object, the 0.25 μm optical projection printer for lithography can be realized by Half-Field Dyson optical configuration.

The development of a confocal Raman microscope represents an important addition to currently available spectroscopic techniques which can provide a wealth of information e.g. sub-surface damage not only in transparent glasses and polymers but in a wide range of other materials, such silicon and germanium

2. Diamond turning and cutting process

In the diamond turning technique, the research work appeared on the following topics:

1). mechanics of material removal
2). development of fast tool servo for non-symmetric elements such as non-symmetric laser optics.
3). cutting special materials, such as polymers.
4). special architecture and algorithms for computer fast control

There are also reports on the chemistry of glass polishing; 3D contouring on a N/C grinder; off-axis optical fabrication; ductile mode grinding of brittle materials; diamond polishing and cutting and planing of diamond film.

3. UNIVERSITY RESEARCH AND EDUCATION PROGRAM IN PRECISION ENGINEERING

There is growing activity in the US universities. In the conference, four universities present either the introductions on their research and education program or open positions to the attendances of ASPE. They are : 1). Precision engineering center in North Carolina State University at Raleigh, which is also the

Headquarters of ASPE. 2). The group of precision engineering in the University of North Carolina, newly organized group. 3). Precision engineering center in Stanford University which has a position open to experienced person in the precision design. 4). CIM Center in the Connecticut University looks for persons at all professor levels on the precision designs.

I had a chance to talk with prof. Robert Hocken, (past chairman of the Nominating Committee of ASPE, Chairman of 1993 Annual Meeting Organizing Committee), the Head of the group of precision engineering, the University of North Carolina. He told me the basic program on the research and education in the group of Precision engineering.

The precision engineering group is an interdisciplinary group, administered through the College of Engineering Technology. The group has both research and academic objectives. Present research efforts include the areas of nanotechnology, eletro-optical instrumentation, atomic force microscopy and optical stethoscope, and dimensional metrology. The nanotechnology is concentrated on development of microscopic machine sensors, and actuators. Research in electro-optical instrumentation includes testing of a high-speed laser tracking system for manufacturing applications and inspection system for turbine blades and blisks. In dimensional metrology efforts are concentrated on advanced probes, controllers, surface measurement systems and database, coordinated computer aided design/drafting systems, computer modeling of machining process, and inspection algorithms for measurement systems, including CMM's.

The academic program has four major thrust areas: 1).design area which is intended to introduce students to the the fundamental principles and techniques of the precision machines of all types; 2). manufacturing area which concentrated toward those who will be using high precision tools for manufacturing of high-value-added, high accuracy components; 3). metrology in which the measurement option has been constructed to give them a proper background for "this important area". 4). control in which the fundamentals necessary for control precision process from the level of servo control system to the more broadly defined computer science for controlling lager systems and

total product quality.

4. Some aspects on research and application of air bearings

The complete intelligent design package of air bearing in the finite difference method will be released in May, 1991, by prof, K. J. Stout, department of mechanical engineering, Birmingham university.

The companies which manufacture air bearings do not provide the dynamic information of the bearing systems, because they do not have people and facility to do so, even customers ask that.

The restrictors used in the commercial air bearings(including used in the commercial machines) in the USA are the orifice restrictors, except the professional instrument company which uses the "surface restriction".

The temperature drop in the air bearings has been not studied, even LLNL uses the concept of "John-Kelvin" effect(in fact, it is wrong idea).

Some statistics The conference has 243 attendances, 17 tutorials, 63 papers, 17 speech in commercial session, 30 companies for exhibitions