

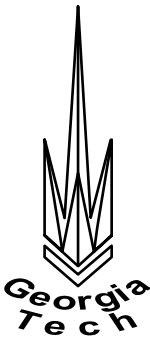
PROCESS CONTROL AND CALIBRATION FOR PRECISION PART PRODUCTION

Presented by Austin Chen
Advisor: Dr. Thomas Kurfess
October 20, 2004

Overview

- ❖ Introduction
 - Problem Statement
 - Research Objective
 - Task and Equipment
- ❖ Current Methods in Machine Tool Metrology
- ❖ Research
- ❖ Expected Contributions

Problem



- ❖ Precision production environment
 - low yield
 - E.g. part demanded ~1 per month
- ❖ Machine the part accurately the first time?
 - Previously
 - ◆ Error mapped
 - ◆ Successful part program
 - What about this time?

Problem Statement

- ❖ There are many techniques for machine tool error characterization
 - Provide information on current and expected machine tool performance
 - Thermal mapping, detection of geometric errors, etc.
 - Error compensation can be applied
 - How does all this research fit together?
- ❖ These methods require
 - Specialized equipment
 - ◆ Expensive
 - ◆ Calibration
 - Operation
 - ◆ Time consuming (testing can span days)
 - ◆ May require meticulous setup

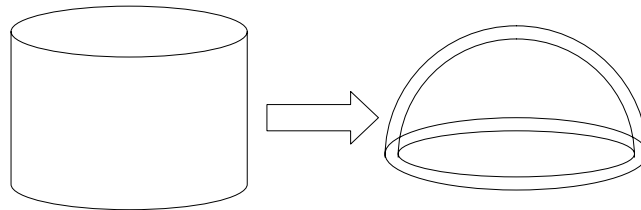
Research Objective

- ❖ To develop a simple and effective methodology, performed prior to machining, to evaluate the machine tool's ability to machine a circular arc profile to tolerance
 - Apply error correction if necessary and possible
 - Integrate existing research

Task

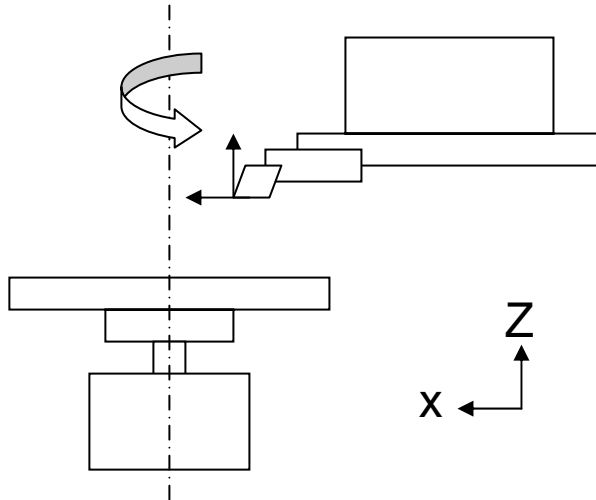
❖ “Object of Interest”

- Turn “hemishell”
- Radius: 50-100 mm (2 – 4 in), within 5 μm
- Wall thickness: 13-20 mm (<1 in), within 10 μm
- Center to center within 10 μm
- Material: Al, then 304 SS



Equipment

- ❖ Okuma & Howa V40R
 - KGK International
- ❖ 2-axis Vertical turning center
- ❖ Fanuc 18i-T CNC

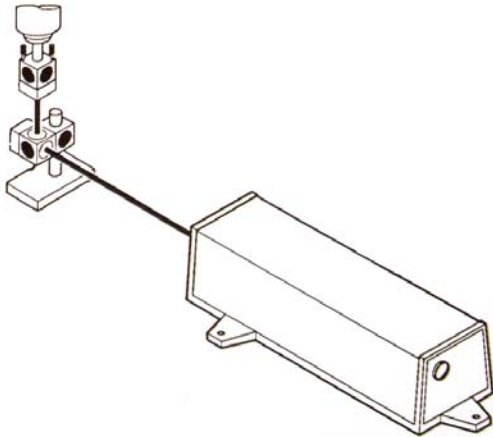


Machine Tool Metrology

- ❖ Interferometer
- ❖ Reversal
- ❖ Ball bar
- ❖ Touch Probe

Interferometer

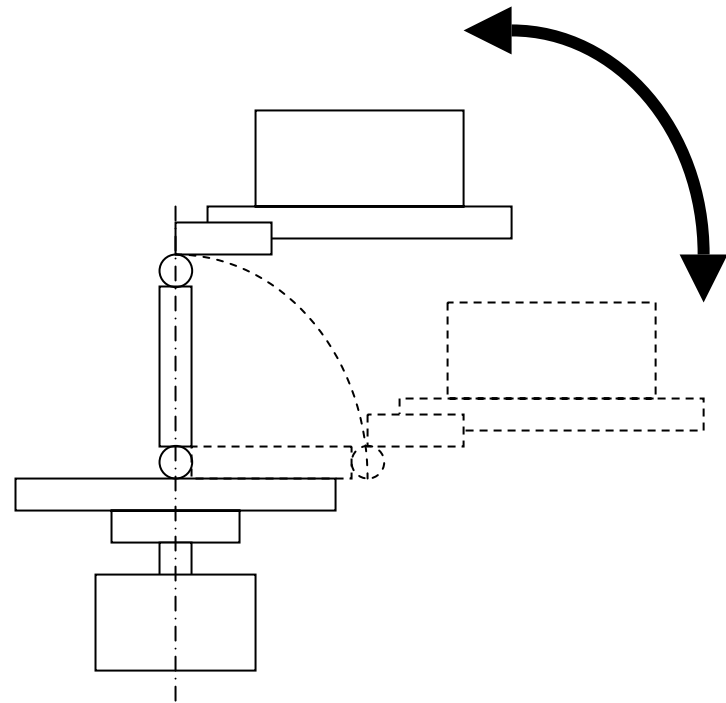
- ❖ HeNe Heterodyne
 - ❖ Accuracy dependent on alignment
 - ❖ Careful alignment
 - ❖ Expensive
- ❖ Operating principle
 - Uses dual frequency laser
 - Uses beat frequency for distance detection



Ballbar

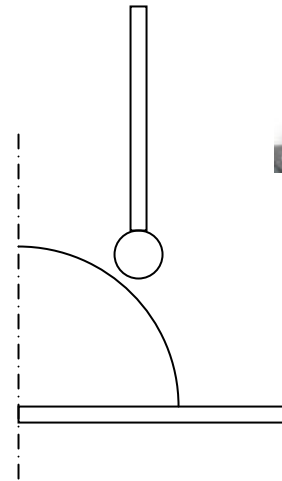
❖ Telescoping Ballbar

- LVDT inside telescoping arm
- Characterize ability to move in circular arc
- Also measure squareness, backlash, servo motor effects...



Touch Probe

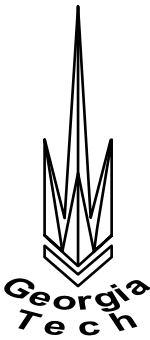
- ❖ Similar to CMM probe
- ❖ Physically contact part
 - tip location registered
- ❖ On-machine probing
 - Same errors affect measurement
 - ◆ Calibration with artifacts



Current Procedures

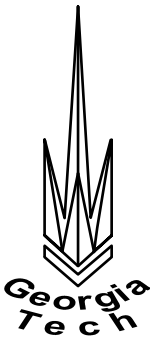
- ❖ Error mapping, characterization, and compensation
 - May not be practical or accessible
 - Expensive equipment
 - Involved setup and operation

Potentially...



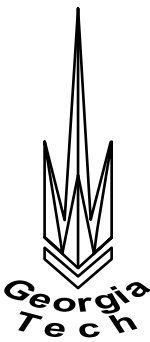
- ❖ Potential events or occurrences between machining operations
 - Machine used for another design/part/operation
 - Recalibrated
 - Machine crash
 - Change of/in environment
 - Different tool/turret
 - Different shutdown/warmup procedure

Research



- ❖ Develop an easy to apply methodology for assessing the machine tool's readiness to machine a hemispherical profile
 - Determine if there have been significant changes in the environment or machine tool.
 - If so, quantify these changes and adjust the tool traj. (G-code) to compensate
 - Identify limitations

Research Tasks



- ❖ Error map machine tool
 - Build error budget
- ❖ Develop methodology focusing on ballbar, on-machine probing and practice
- ❖ Investigate compensation via traj. planning
- ❖ Characterize relationship between machine tool and part
- ❖ Characterize limitations

Contributions

- ❖ Development of a practical methodology for evaluating the ability of a machine tool to machine a specified part
- ❖ Development of a simple method for assessing machine tool performance that integrates the characterization of different sources of error
 - Integrates work done in analyzing various specific error sources
- ❖ Development of a methodology to characterize tool wear indirectly via an on machine touch probe
- ❖ Development of a simplified compensation strategy using modified G code