PROCESS CONTROL AND CALIBRATION FOR PRECISION PART PRODUCTION

Presented by Austin Chen
Advisor: Dr. Thomas Kurfess
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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?
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...

Photo from Renishaw website.
**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