Industrial Advisory Board Meeting

Miniaturization of Machine Tools

Daniel Cox
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Outline

- Objective and Motivation
- Machine Setup
- Experimental Results
- Theoretical Calculations
- Conclusion

Introduction – Motivation – Setup – Results – Calculations – Conclusion
Project Objective

- Design, Construct, and Evaluate a Miniaturized Machine Tool
- Machine Tool Specifications
  - Total Volume ~0.01m³
  - CNC Machine Functionality
  - Submicron Feature Size and Surface Finish
Motivation

- Demand for microscale components for biomedical, computer/consumer electronics, and aerospace applications
- Fewer material restrictions than chemical, energy beam, and silicon etching processes
- Ability to create true three dimensional features unlike layering methods
Experimental Setup

- **Positioning Table**
  - 4 Axis Table
  - Resolution: 10nm x 10nm x 4nm

- **Machine Tool Frame**
  - Solid Invar

- **Video Microscope**
  - 50x-200x

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Experimental Setup Cont’d

- **Spindle**
  - Electric DC Motor
  - Hybrid Bearings
  - 60,000 RPM
  - Runout < 1µm

- **Cutting Tool**
  - Solid Carbide
  - 2-Flute, Square End
  - Tip Diameter Size: 50-200µm

100 mm Diameter Tool
Experimental Results

One Dimensional Test: Straightness Error

Error vs. depth of cut and feed velocity

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Experimental Results Cont’d
Two Dimensional Test: Circle Errors

Percentage form error at 20 mm depth of cut and surface roughness plot

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Experimental Results Cont’d
Three Dimensional Test: Sculptured Surface

Computer generated model and machined part of the sculptured surface (1mm x 1.5mm)

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Theoretical Calculations

- Force Models
- Failure Curve
- Deflection Models

Theoretical calculations for tool failure

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Next Phase of Development

○ Redesigned Machine Tool
  ● Smaller, Stiffer Frame
  ● More accurate Positioning Table
  ● Increased Measurement Ability

○ Fabricate Micro Parts with Even Greater Precision

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Conclusion

- Brief discussion of purpose for microscale machining
- Overview of current miniaturized machine tool
- Description of experimental results
- Sampling of theoretical results