Characterization and Modeling of the Holding Force in a Magnetic Chuck

Precision Machining Research Consortium
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Adequate tangential holding force needed to prevent workpiece slip in precision machining operations.
Contact surface conditions influence workpiece holding forces and hence workpiece slip.
Objectives

- Characterize and model the effects of:
  - Workpiece surface attributes (texture, flatness)
  - Workpiece geometry (dimensions)
  - Material properties (hardness, microstructure)

on the normal and tangential holding forces in an electromagnetic chuck.
Experimental Work

- Study the effects of workpiece surface finish and flatness on the normal and tangential holding force.
Experimental Setup

- Air Cylinder
- Electromagnetic Chuck
- Workpiece
- Piezoelectric Loadcell
- Strain Gage Loadcell
- Tangential Force
- Normal Force
Experimental Results

Tangential Force vs. Flatness

- 2G refers to a ground specimen with 2 μm Ra.
- 2HT refers to a hard turned specimen with 2 μm Ra.
Experimental Results

1.25G refers to a ground specimen with 1.25 µm Ra.

1.25 HT refers to a hard turned specimen with a 1.25 µm Ra.
Theoretical Work

- Modeling the holding force:
  - Considering the nonlinearity of the magnetic properties of the chuck and workpiece materials.

\[
W = \text{Energy} \\
F = -\frac{\partial}{\partial x}(\text{Energy})
\]

- Using the Reluctance Network Method.
Summary

- The experimental results suggest a strong effect of the flatness on the Normal Force required to pull the workpiece from the chuck.
- The effect of surface finish on the normal force is negligible compared to that of flatness.
- Theoretical models of the holding force are currently being developed.