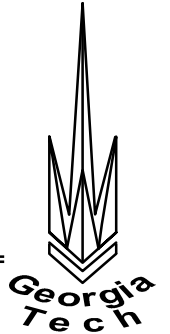


Characterization and Modeling of the Holding Force in a Magnetic Chuck



Precision Machining Research Consortium

Industrial Advisory Board

Georgia Institute of Technology

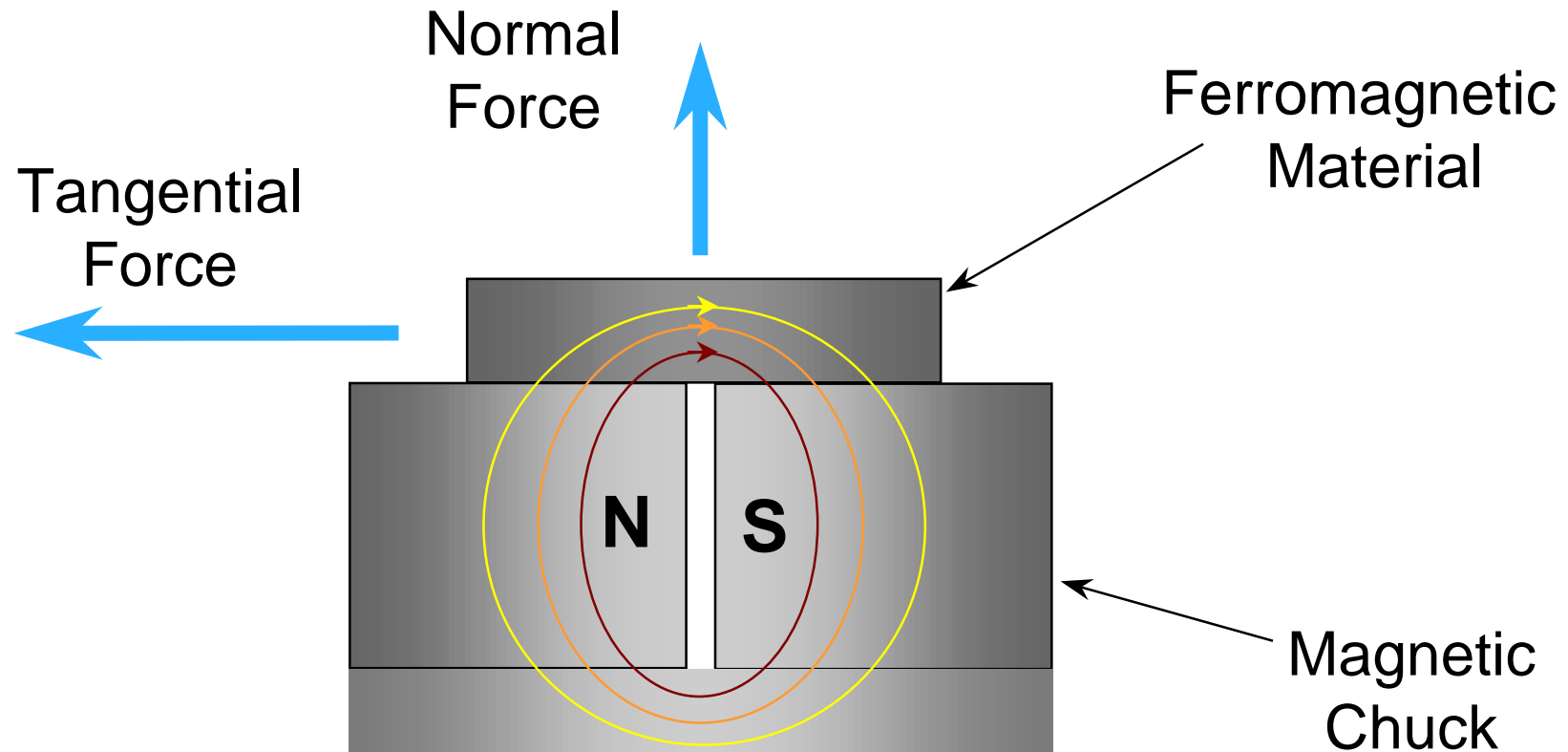
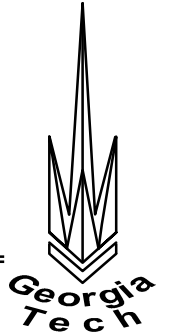
29 October 1997

Alejandro Felix

Robert Schmitt

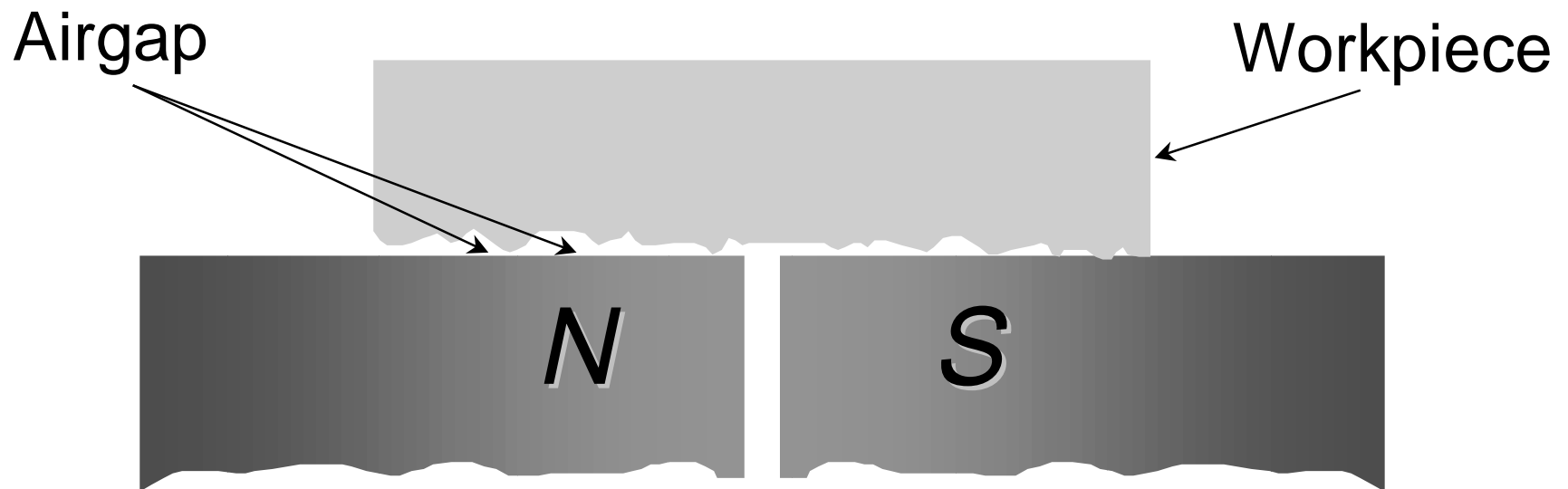
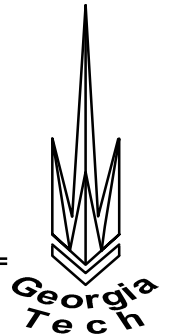
Advisor: Dr. Shreyes N. Melkote

Introduction



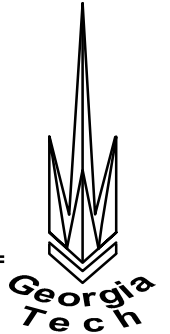
Adequate tangential holding force needed to prevent workpiece slip in precision machining operations.

Introduction (Cont.)



- Contact surface conditions influence workpiece holding forces and hence workpiece slip.

Objectives

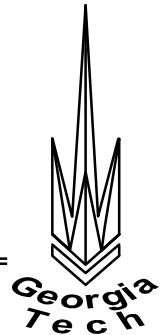


❖ Characterize and model the effects of:

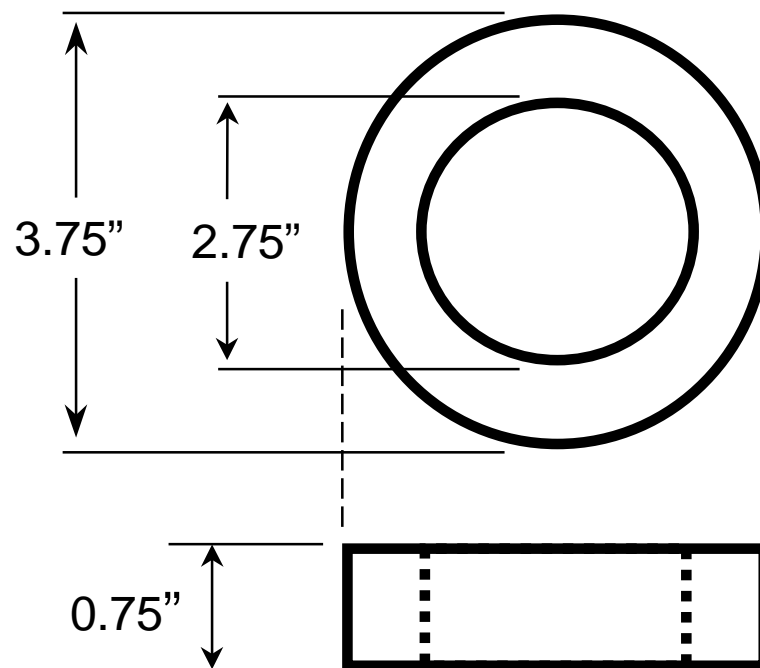
- Workpiece surface attributes (texture, flatness)
- Workpiece geometry (dimensions)
- Material properties (hardness, microstructure)

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

Experimental Work

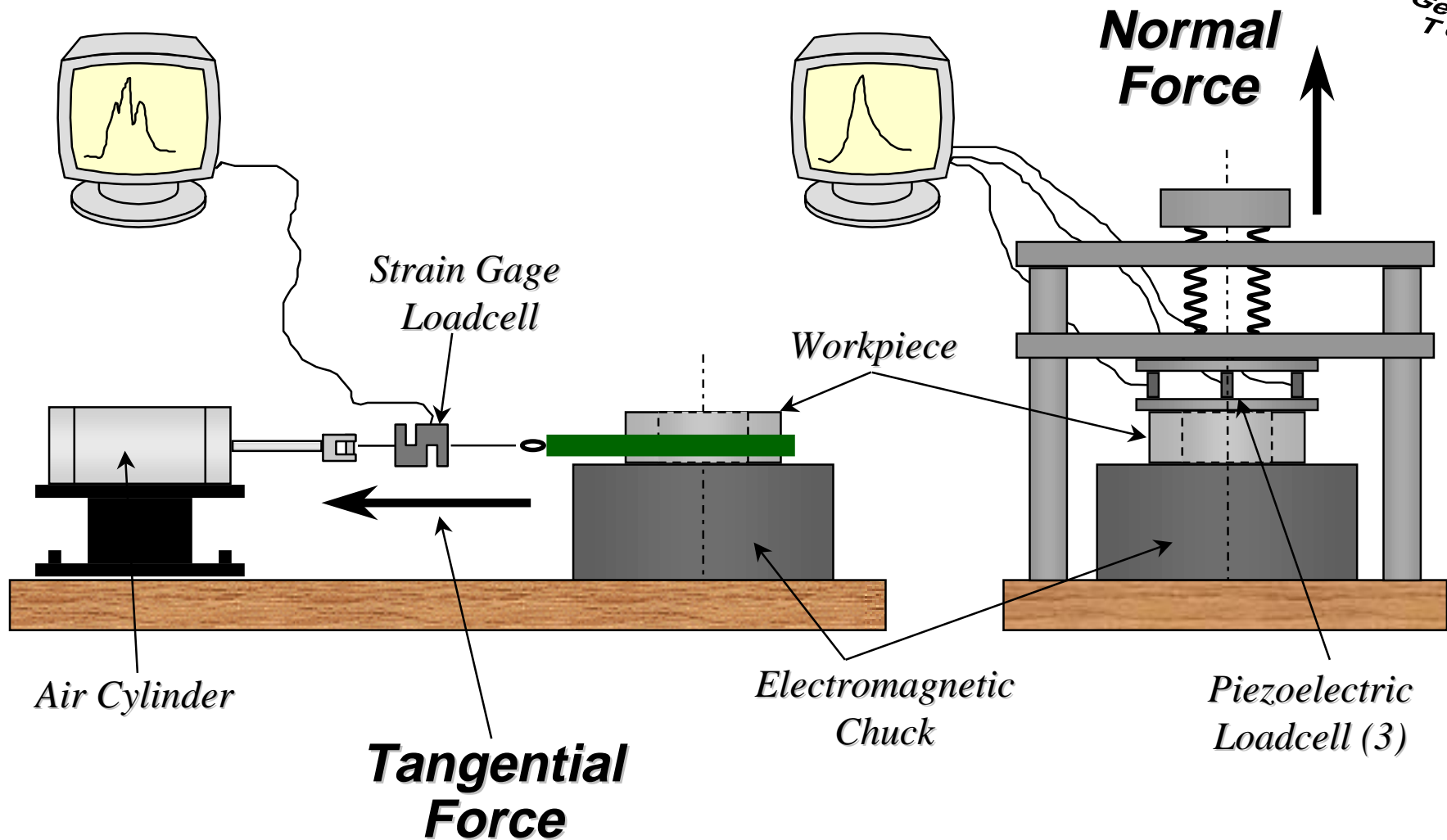


- ❖ Study the effects of workpiece surface finish and flatness on the normal and tangential holding force.



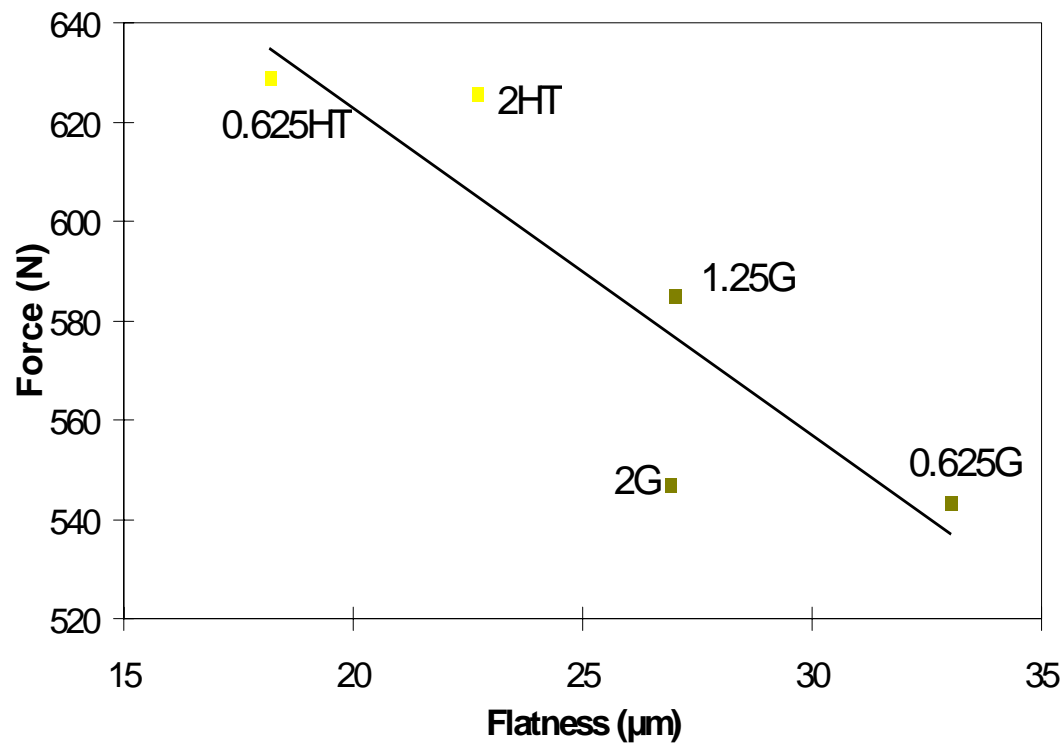
Workpiece Geometry

Experimental Setup

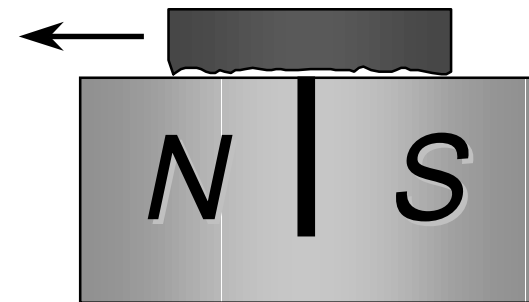


Experimental Results

Tangential Force vs. Flatness

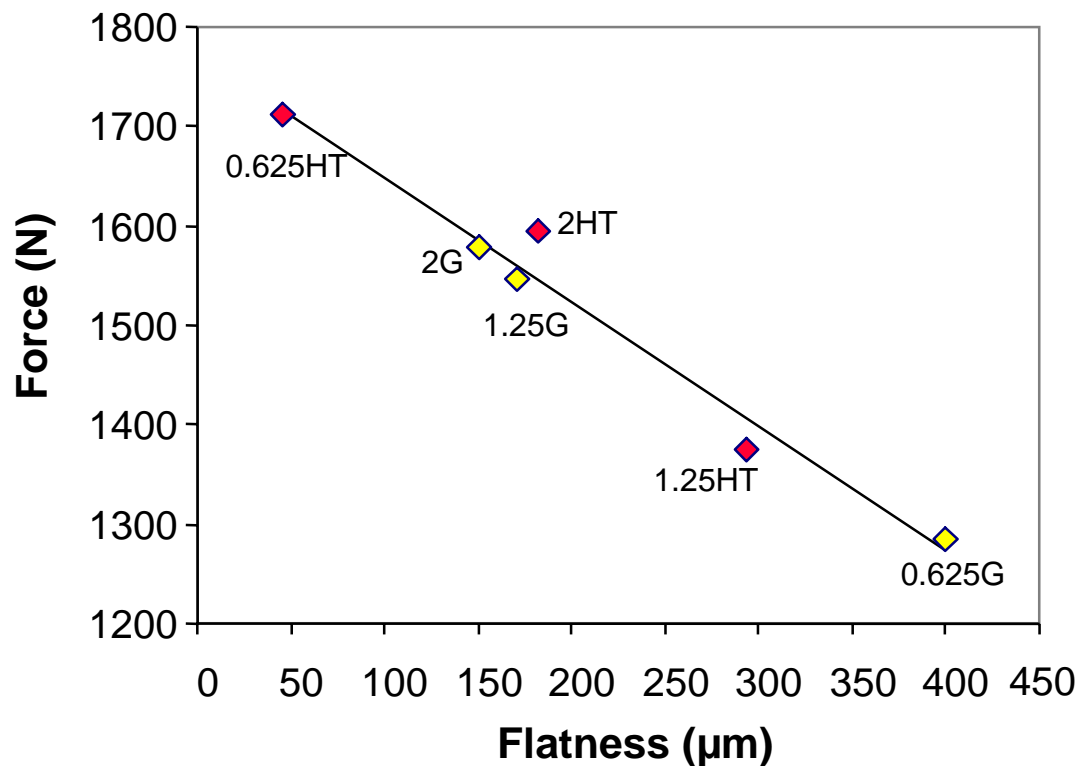


- **2G** refers to a ground specimen with $2\text{ }\mu\text{m Ra}$.
- **2HT** refers to a hard turned specimen with $2\text{ }\mu\text{m Ra}$.

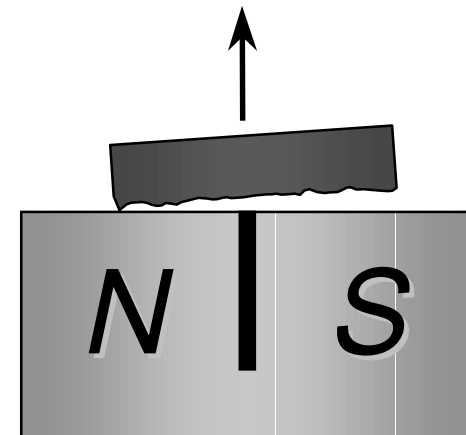


Experimental Results

Normal Force Measurement Vs Flatness



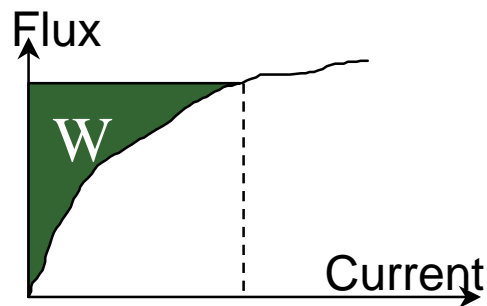
- 1.25 **G** refers to a ground specimen with 1.25 μm Ra.
- 1.25 **HT** refers to a hard turned specimen with a 1.25 μm Ra.



Theoretical Work

❖ Modeling the holding force:

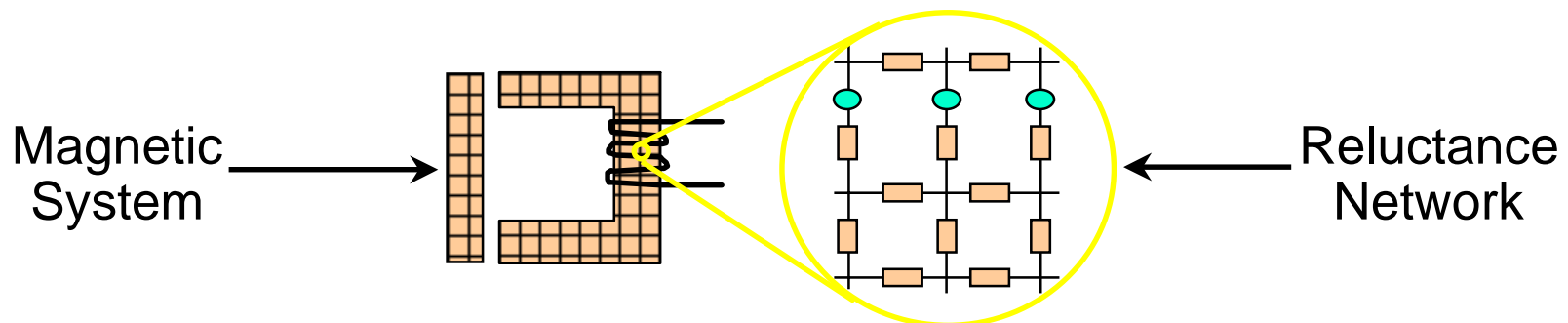
- Considering the nonlinearities of the magnetic properties of the chuck and workpiece materials.



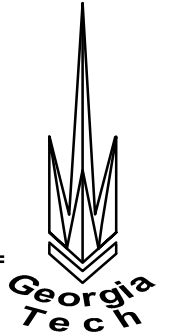
$$W = \text{Energy}$$

$$F = -\frac{\partial}{\partial x}(\text{Energy})$$

- 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.