

Surface Roughness Effects on the Head-Tape Interface

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Outlines

- Head-tape interface modeling (mechanics)
- Head-tape contact and tape asperity compliance
- Asperity compliance: experimental determination
- Head-tape spacing for a transversely slotted head
- Head-tape spacing for a cylindrical head
- Surface roughness and tape asperity compliance
- Conclusions

Objectives

- Investigate the effect of surface roughness on the head-tape interface using tapes with different surface roughness against
 - transversely slotted head
 - cylindrical head
- Determine the tape surface asperity compliance
- Establish relationship between asperity compliance and surface roughness parameters
- Develop numerical model for head-tape interface including the effect of surface roughness

Head-Tape Interface Configuration

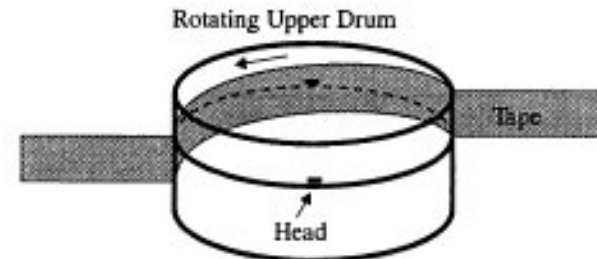
Longitudinal

- head stationary
- tape moves
- low data rate for single head, use heads in parallel



Helical Scan

- head on rotating scanner
- tape moves slowly
- high data rate for single head



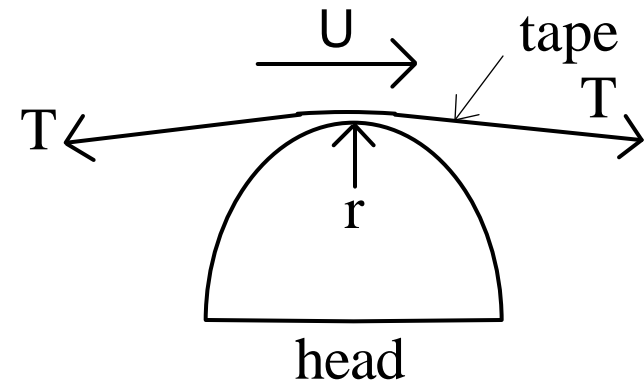
(Both pictures taken from *C. Lacey: Head/Tape Interface*)

Linear Head-Tape Interface (No Contact)

- **Hydrodynamic lubrication equation**

$$\frac{\partial}{\partial x} \left[ph^3 \left(1 + \frac{6\lambda}{h} \right) \frac{\partial p}{\partial x} \right] = 6\mu U \frac{\partial(ph)}{\partial x}$$

where **h** = head-tape spacing,
p = **p_a** = air bearing pressure,
λ = mean free path of air,
μ = air viscosity, and
U = tape velocity.



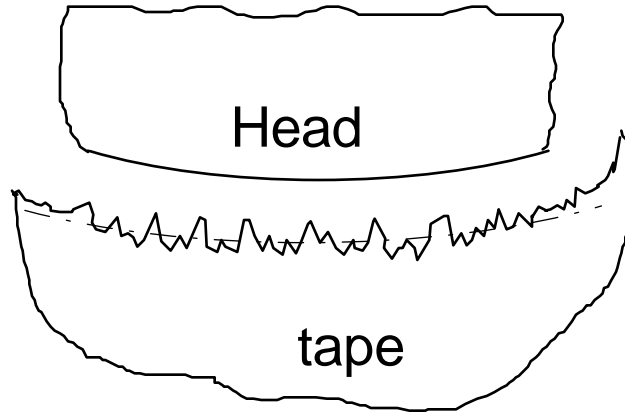
- **Tape elasticity equation**

$$D \frac{\partial^4 w}{\partial x^4} - (T - \rho U^2) \frac{\partial^2 w}{\partial x^2} = p - p_{\text{atm}}$$

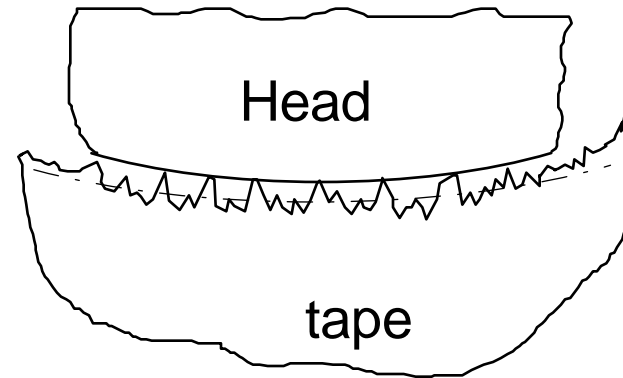
where **D** = tape bending stiffness,
T = tape tension,
U = speed,

w = tape deflection,
ρ = tape density,
p_{atm} = atmospheric pressure.

Schematic of Head-Tape Configuration



no contact



contact

Linear Head-Tape Interface (with Contact)

- **Hydrodynamic lubrication equation**

$$\frac{\partial}{\partial x} \left[\rho h^3 \left(1 + \frac{6\lambda}{h} \right) \frac{\partial p}{\partial x} \right] = 6\mu U \frac{\partial(\rho h)}{\partial x}$$

where h = head-tape spacing, $p = p_a$ = air bearing pressure,
 λ = mean free path of air, μ = air viscosity, and
 U = tape velocity.

- **Tape elasticity equation**

$$D \frac{\partial^4 w}{\partial x^4} - (T - \rho U^2) \frac{\partial^2 w}{\partial x^2} = p - p_{atm} + p_c$$

where D = tape bending stiffness, w = tape deflection, T = tape tension,
 ρ = tape density, U = speed, p_{atm} = atmospheric pressure and p_c =
 head-tape contact pressure.

- **Head-tape contact equation (see next slide)**

Head-tape Contact Models

- Empirical model:
$$p_c = \begin{cases} 0, & h \geq \alpha, \\ \beta(1-h/\alpha)^2, & h < \alpha. \end{cases}$$

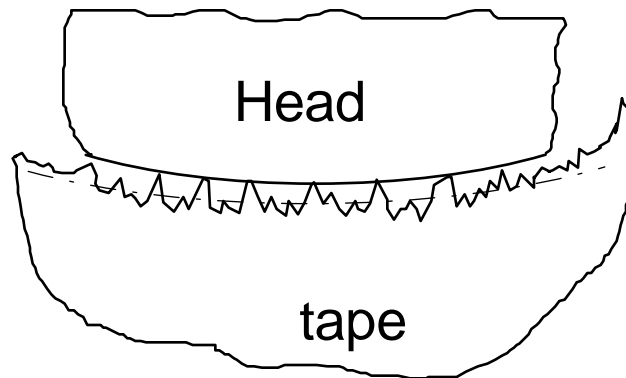
where α a constant denoting the spacing for which initial contact occurs between the head and the tape and β is a constant denoting the contact pressure that exists if the head-tape spacing is zero.

- Greenwood-Williamson model:

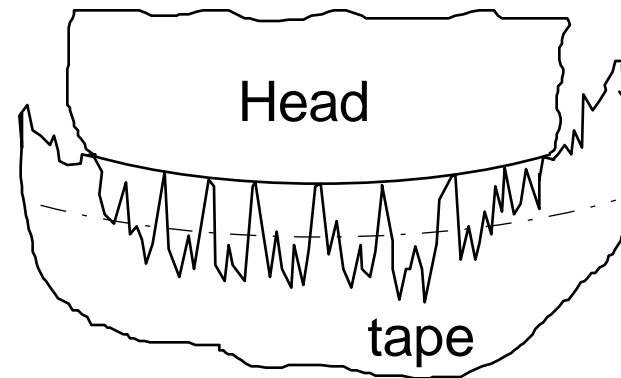
$$p_c \left(\frac{h}{\sigma} \right) = K \int_{\frac{h}{\sigma}}^{\infty} \left(z^* - \frac{h}{\sigma} \right)^2 \Phi(z^*) dz^*$$

where σ is a roughness parameter, K is the contact pressure coefficient.

Schematic of Head-Tape Contact



smooth tape



rough tape

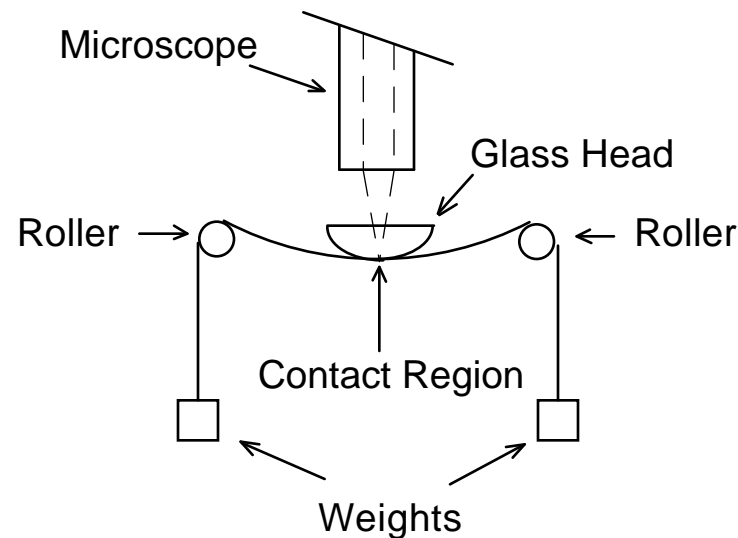
Tape Asperity Compliance: Experimental Determination

A. Tape Tension Method

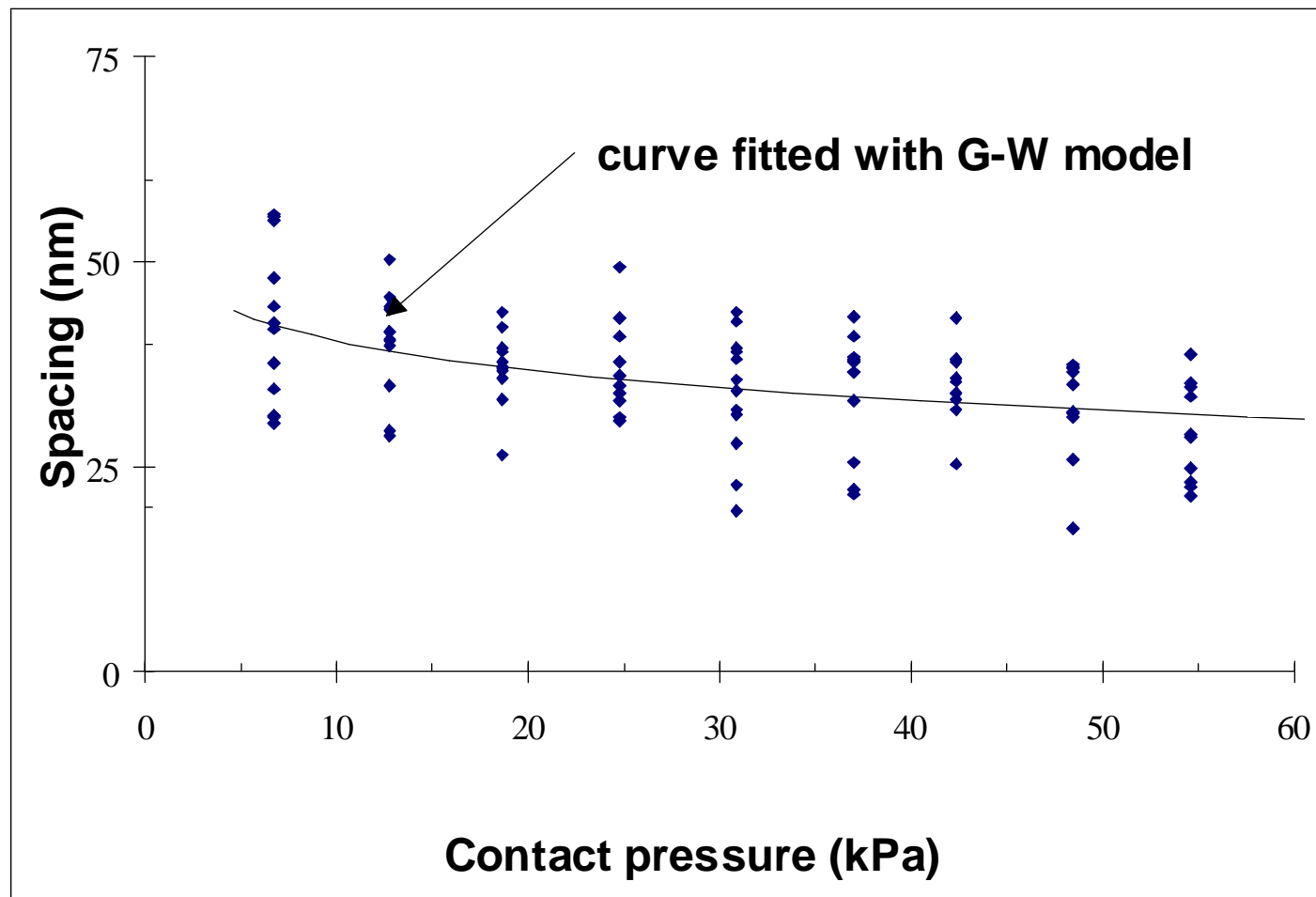
The contact pressure (p) is determined using the equation

$$p = \frac{T}{r}$$

where T is tension and r is the radius of the head

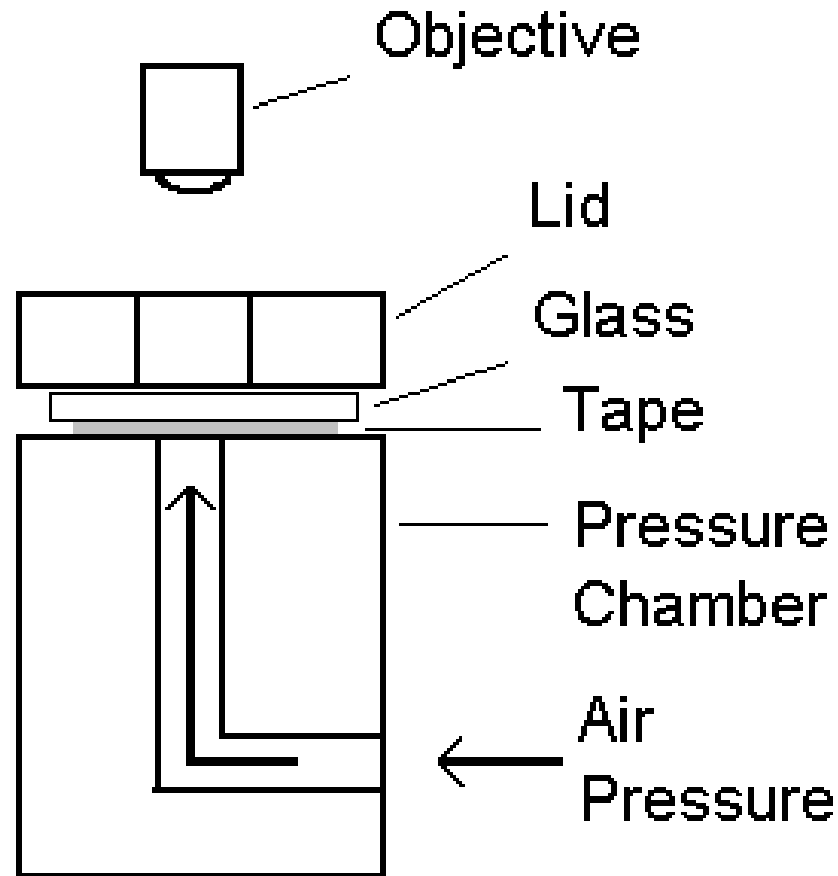


Asperity Compliance Using Tension Method



Note: High contact pressure is difficult to obtain

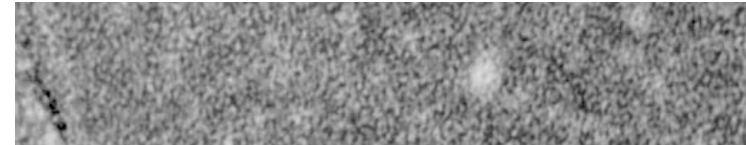
Improved Method: Pneumatic Method



Observation: Contact Region Becomes Darker as the Pressure Increases



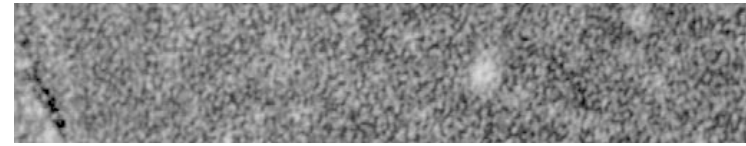
5.05 psi



19.57 psi

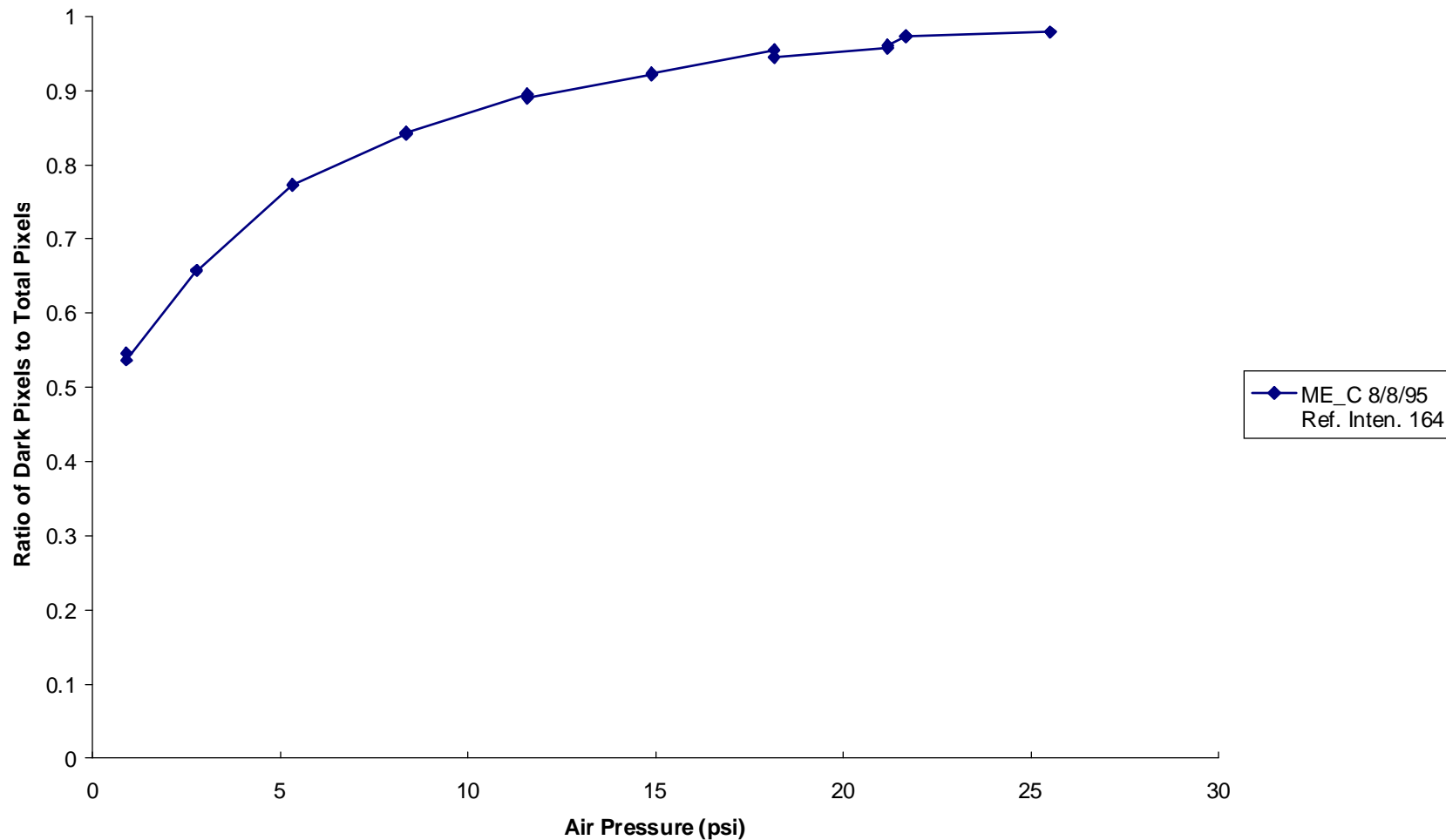


10.49 psi

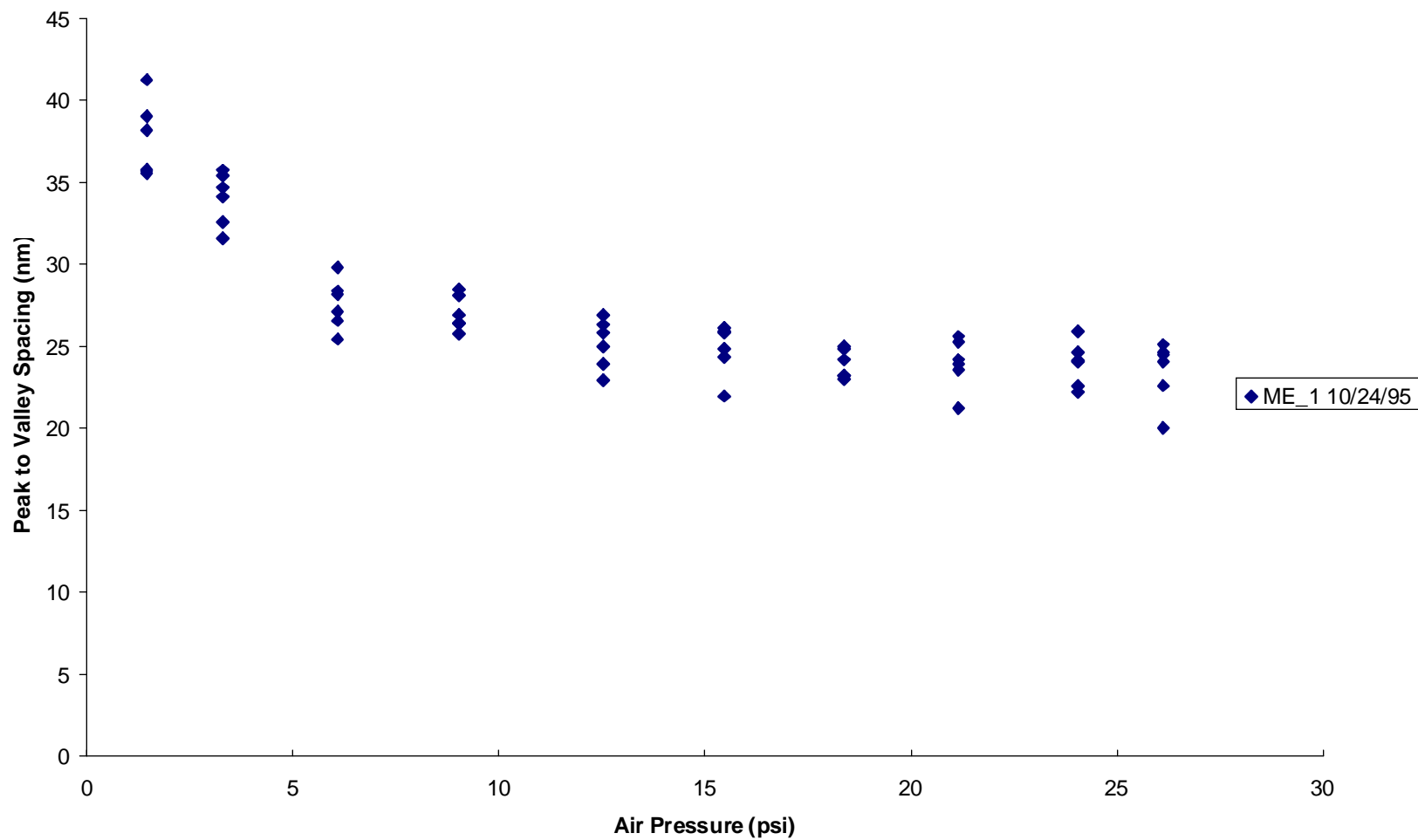


25.35 psi

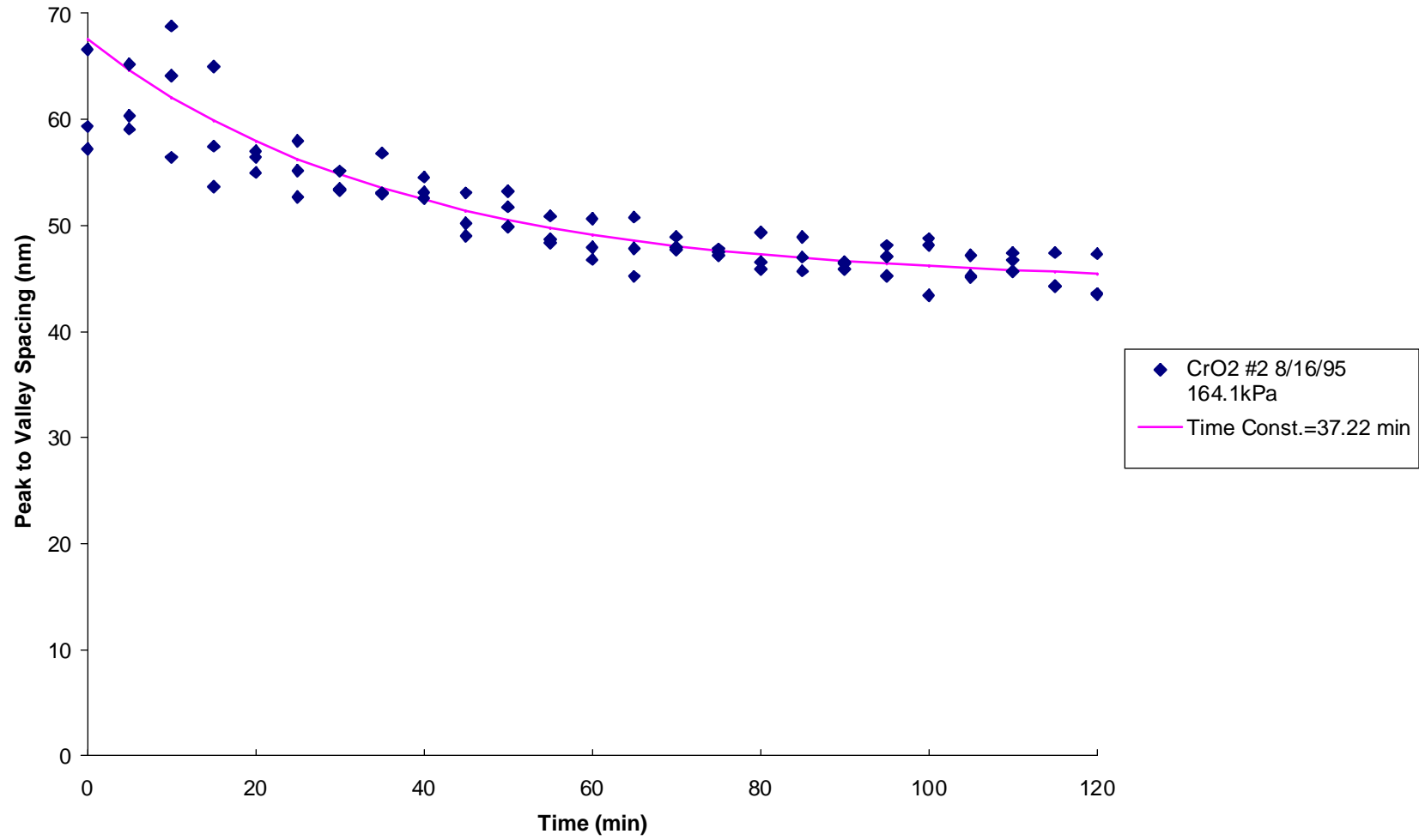
Asperity Compliance (Pneumatic Tester)



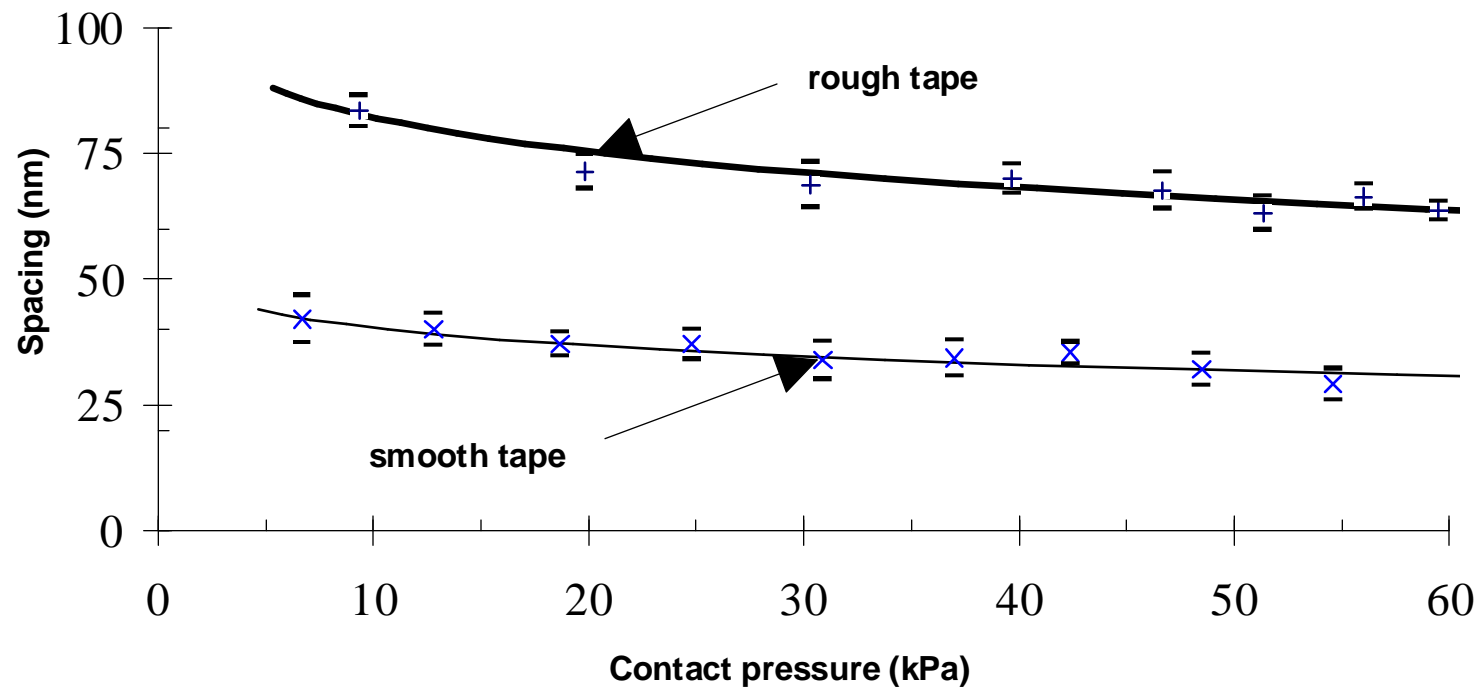
Asperity Compliance (Pneumatic Tester) Metal Evaporated Tape



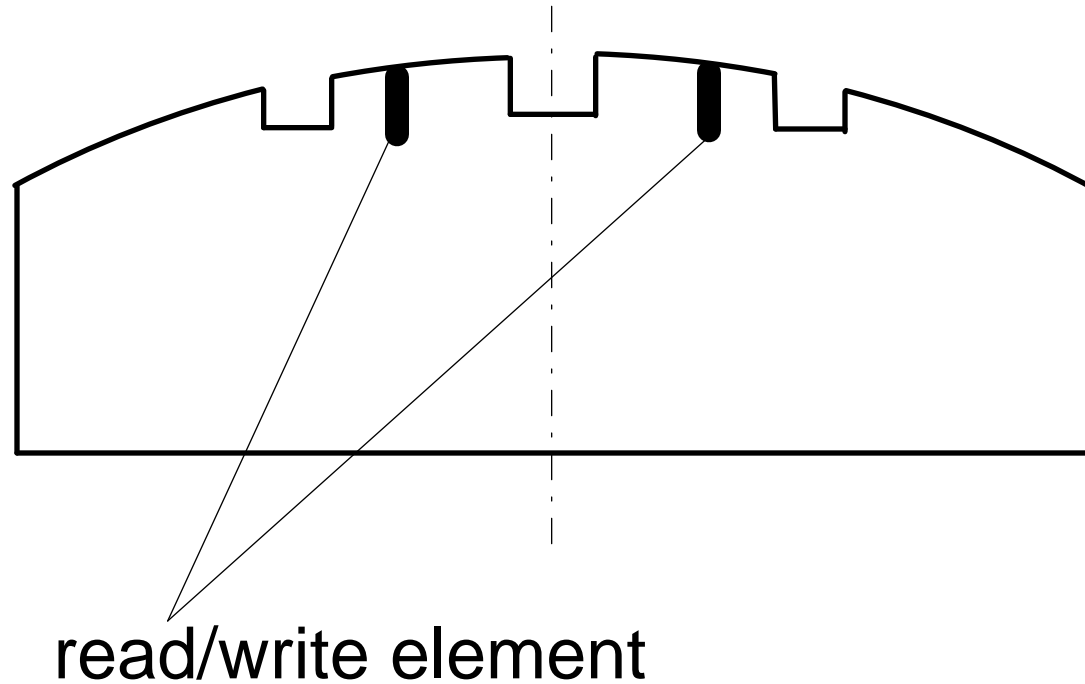
The Effects of Time on Spacing (Pneumatic Tester) Chromium Dioxide Tape



Asperity Compliance Curves of Two Tapes with Different Surface Roughness

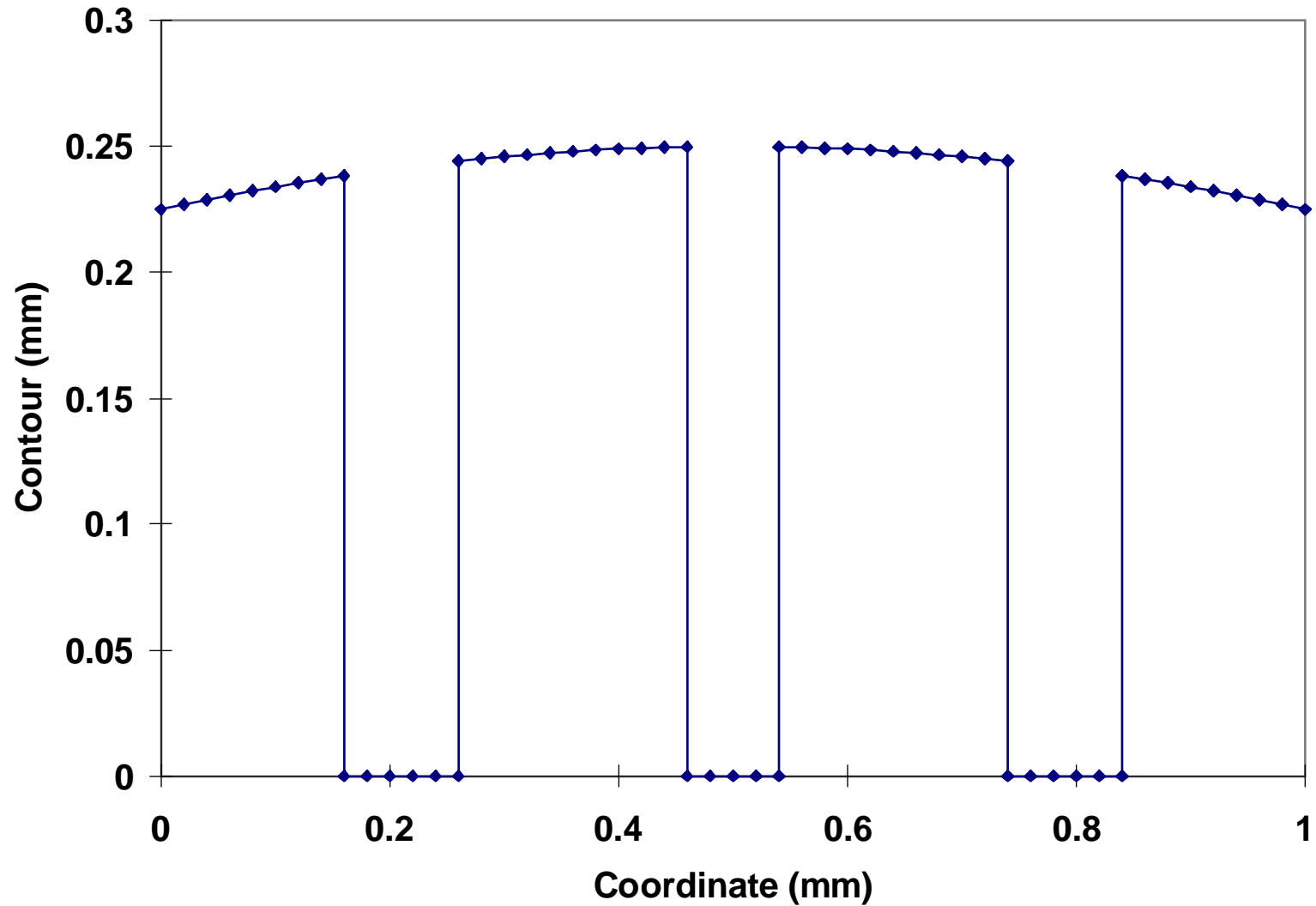


Head Contour Schematic

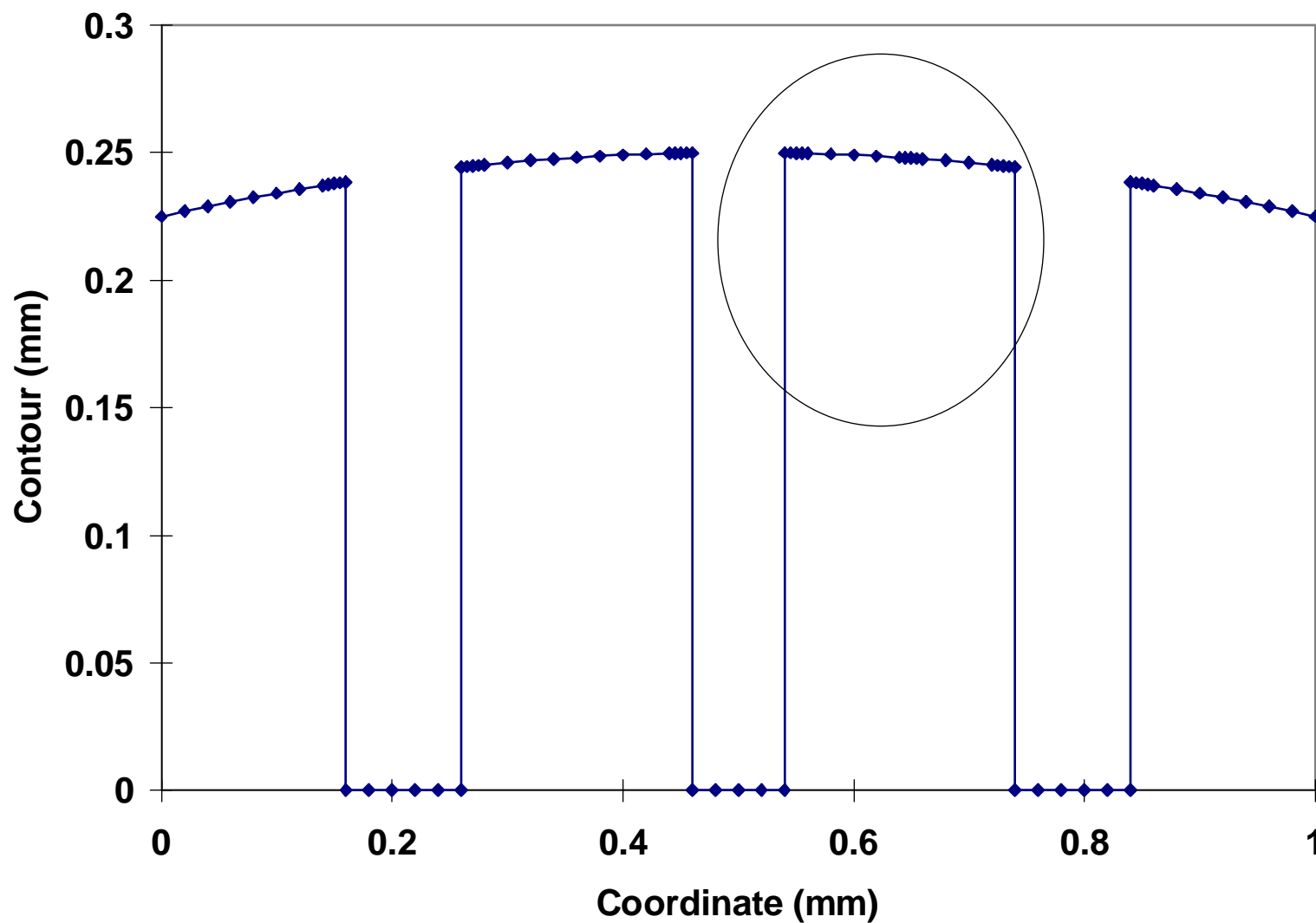


Cross-section of head with transverse slots

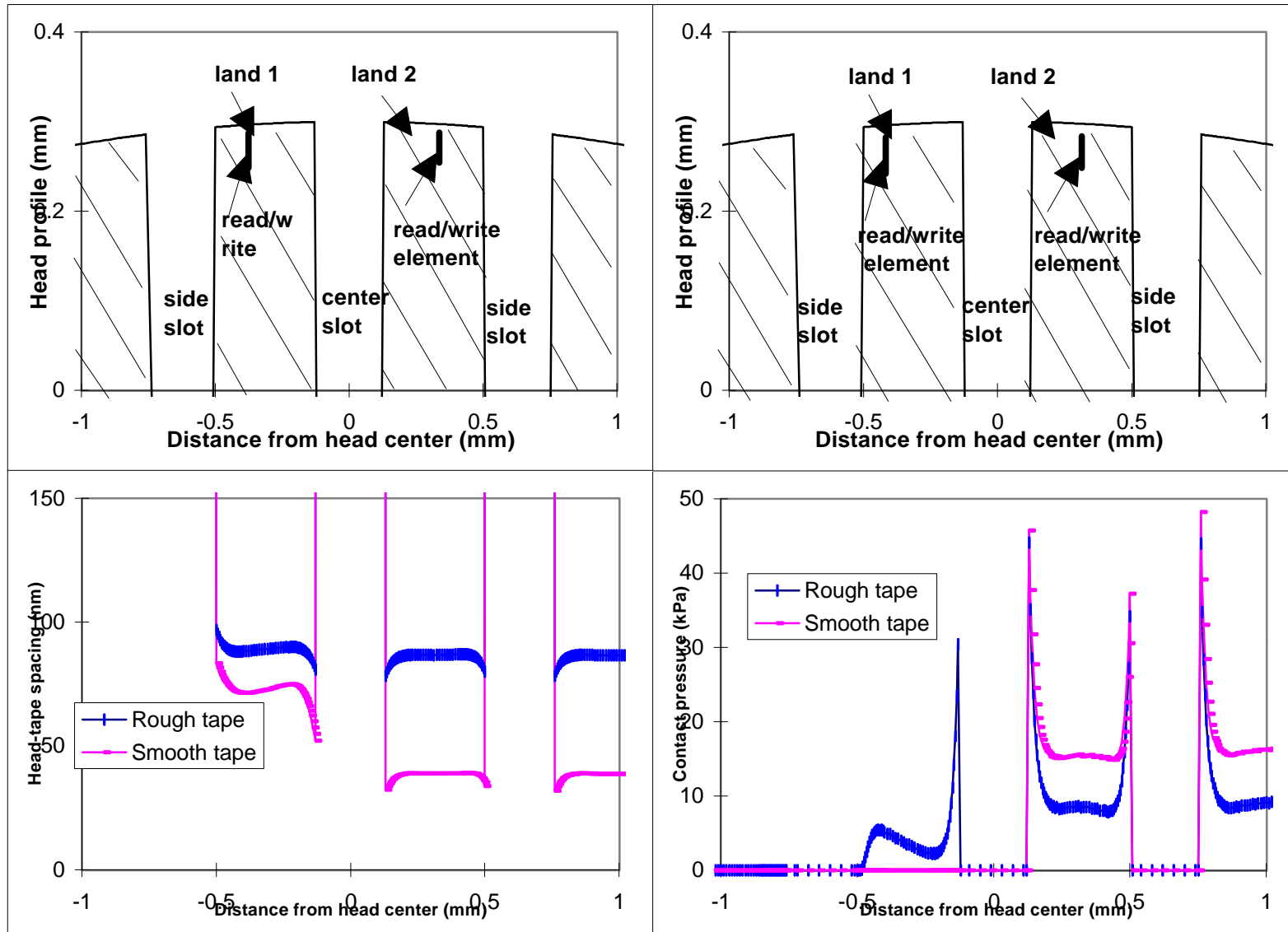
Head Contour Discretization: Uniform Grid



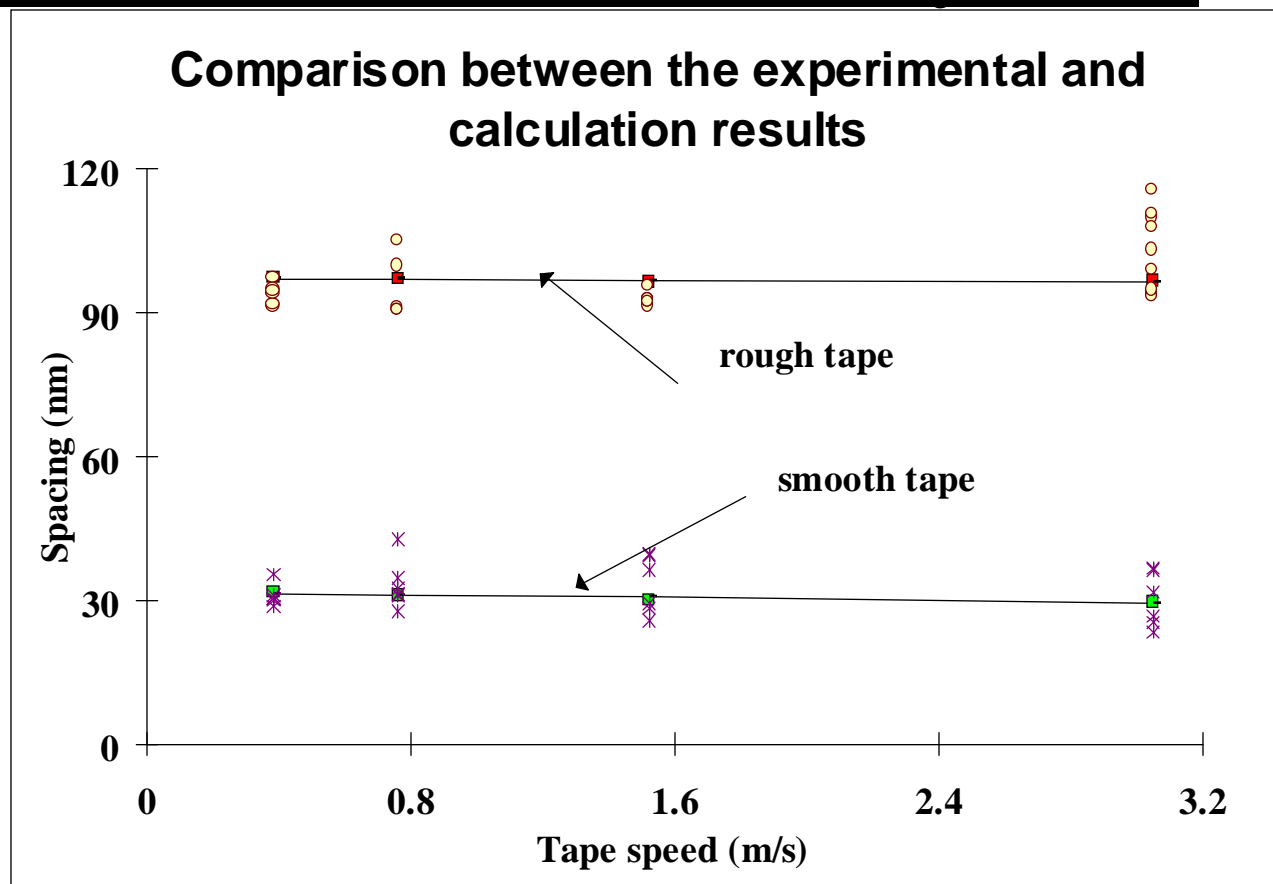
Head Contour Discretization: Non-uniform Grid



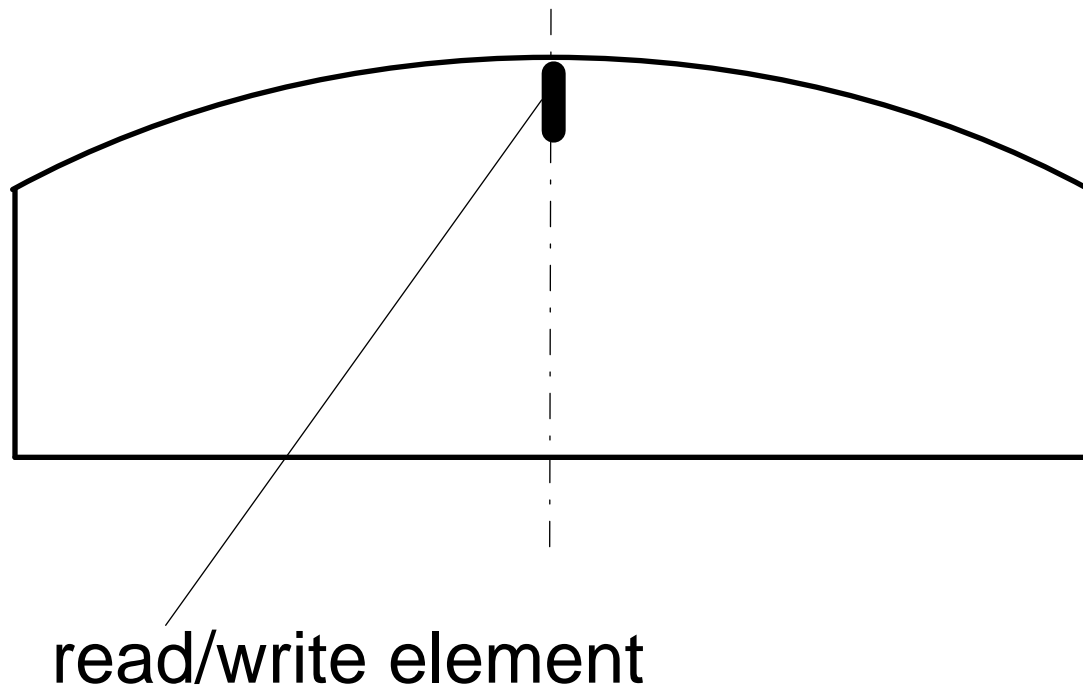
Calculation Results



Head-Tape Spacing versus Tape Speed for a Head with Transversely Slots

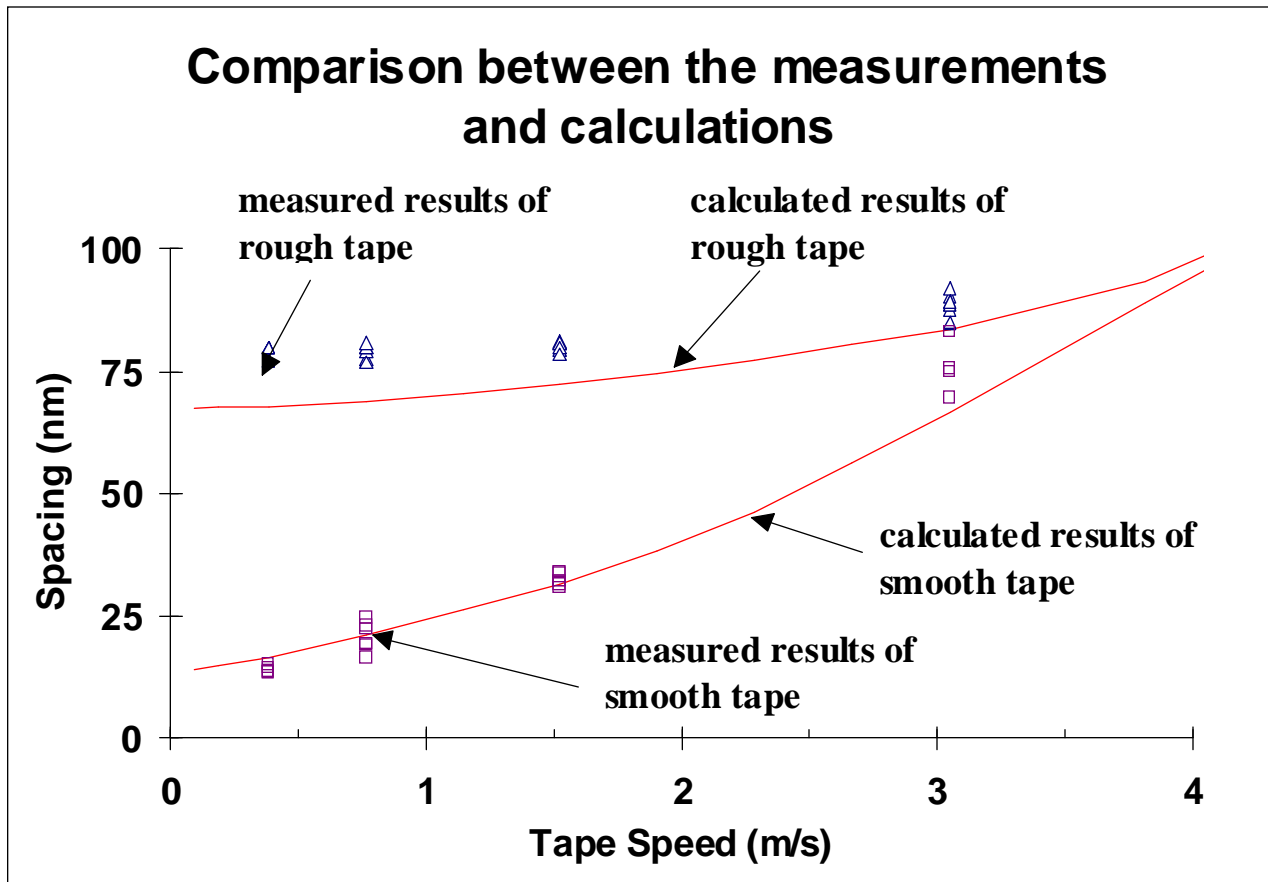


Head Contour Schematic

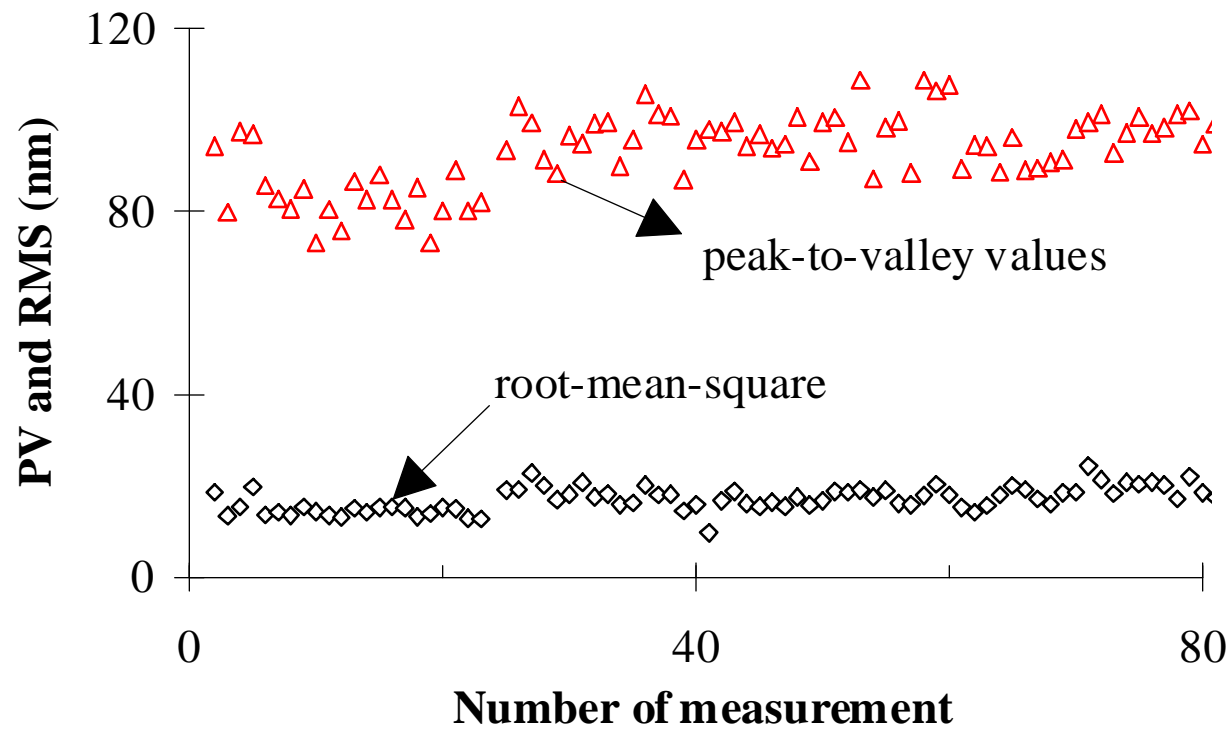


Cross-section of a cylindrical head

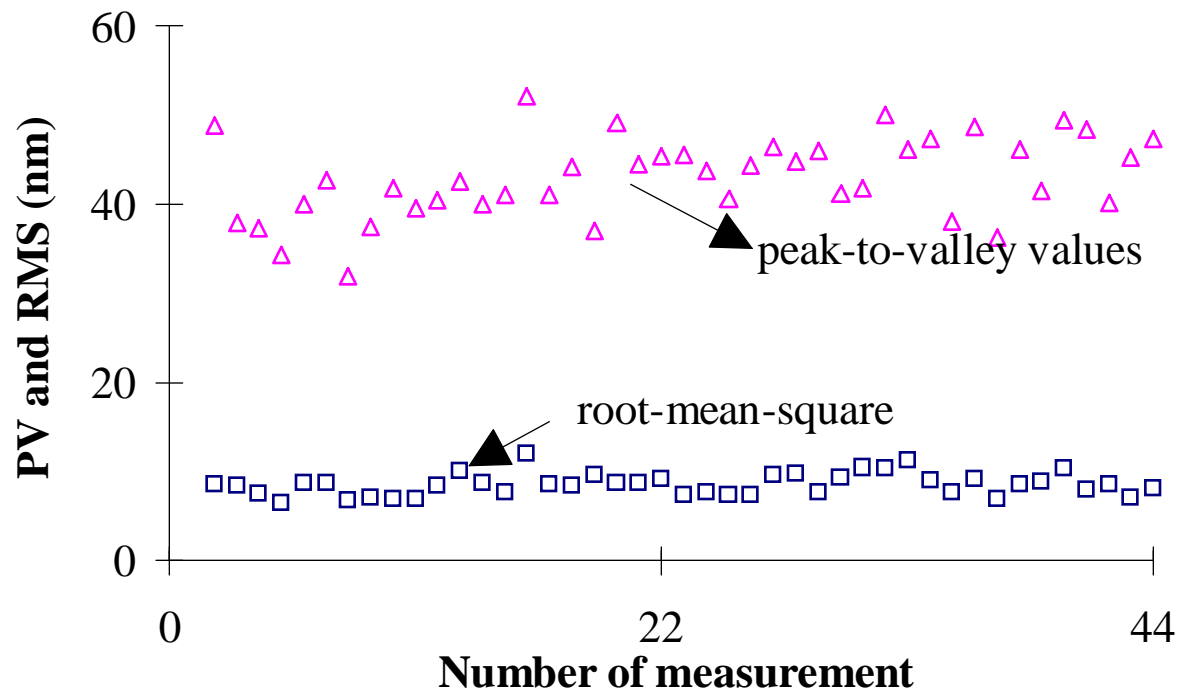
Head-Tape Spacing versus Tape Speed for a Cylindrical Head



Surface Roughness of Rough Tape



Surface Roughness of Smooth Tape



Comparison of Surface Roughness Values and Asperity Compliance Parameters

Table 1: Surface roughness of typical tapes		
Tape	rough	smooth
RMS (nm)	17.9	8.55
P-V (nm)	95.8	43.0
α (nm) (“parabolic” model)	93.4	48.0
3σ (nm) (G-W model)	94.5	48.0

Conclusions

- **Surface roughness is an important parameter in the head-tape interface**
- **Rough tape \Leftrightarrow large spacing**
Smooth tape \Leftrightarrow small spacing
- **Head-tape spacing is surface roughness limited, i. e., to obtain small spacing, tape surface roughness must be reduced**
- **Peak-to-valley roughness rather than RMS or CLA(center line average) roughness determines the head-tape spacing**
- **Variable grid mesh is efficient for head wear calculation using finite element based simulator**