SWTW18-14

Optimizing cleaning processes based on force to puncture ITS materials

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Introduction

- Perform Force vs. over travel (OT) tests to determine the yield strength of elastic probe cleaning materials.
- Compare and validate experimental results to a theoretical model.
- Consider polymer elasticity properties for determination of optimal cleaning processes.
- Evaluate effect of probe area to puncture force through material surface.

Test Parameters

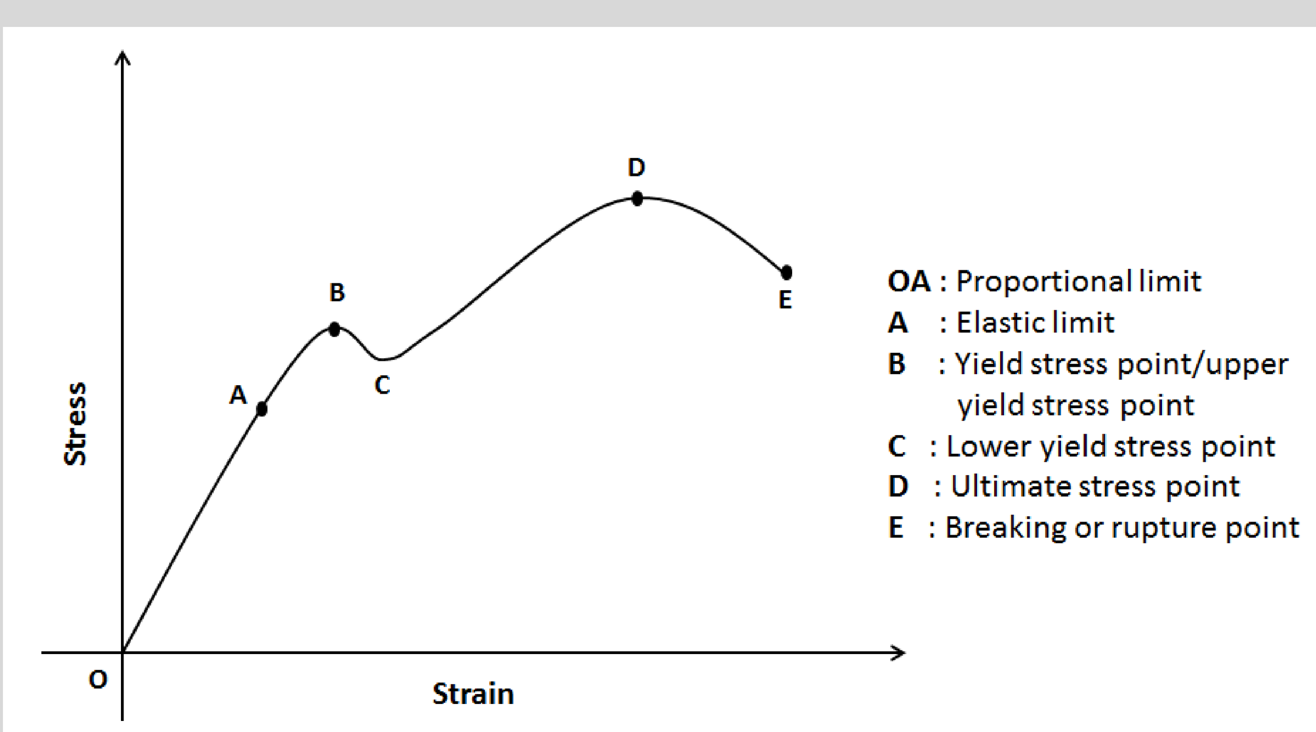
Probe Size	(Vertical – 100um, 76.2um, 50.8um)				
Materials Used	PV-OE0E	PV-AD0E	PF-AHHE	PP150-03	PP300-03
Cleaning Material	—	—	—	xx	xxx
Shaping Material	x	xx	xxx	—	—
Max OT			230um		
Temperature			25C		

x = abrasiveness

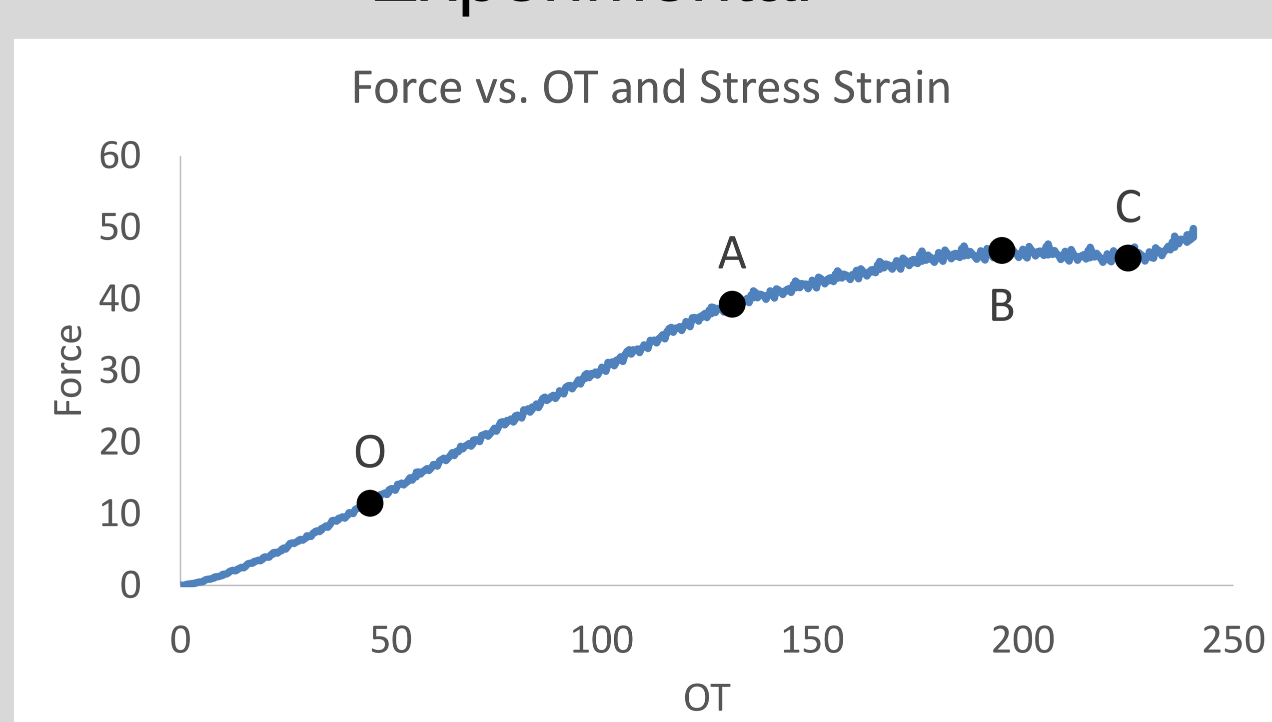
Mathematical Model

- Force was measured as a function of over travel on various elastomeric materials.
- The waveforms produced (right) are comparable with a stress-strain curve for ductile materials (left).
- As the probe approaches the force at the elastic limit (A), it will begin to penetrate through the surface of the polymer.

Theoretical



Experimental



$$Y.S. = \frac{F_y}{A_p}$$

$Y.S.: Yield\ Strength\ (constant)$

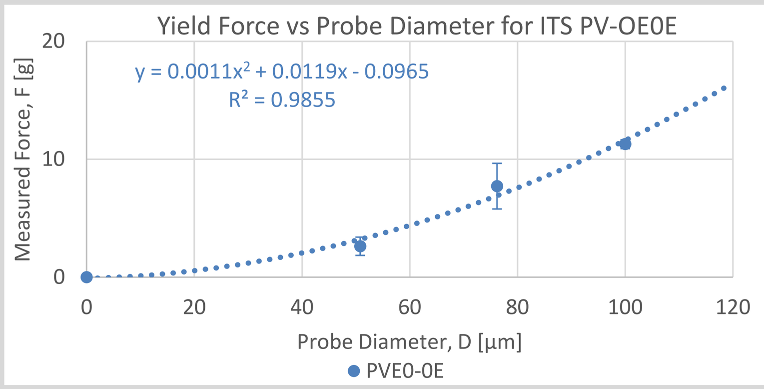
$F_y: Force\ Requried\ for\ Yielding$

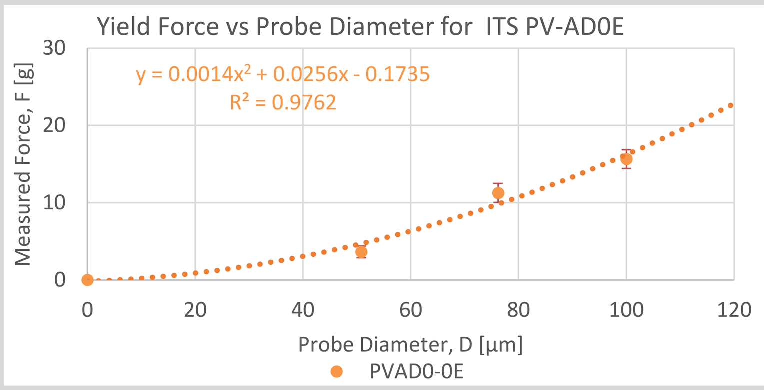
$A_p: Probe\ Area$

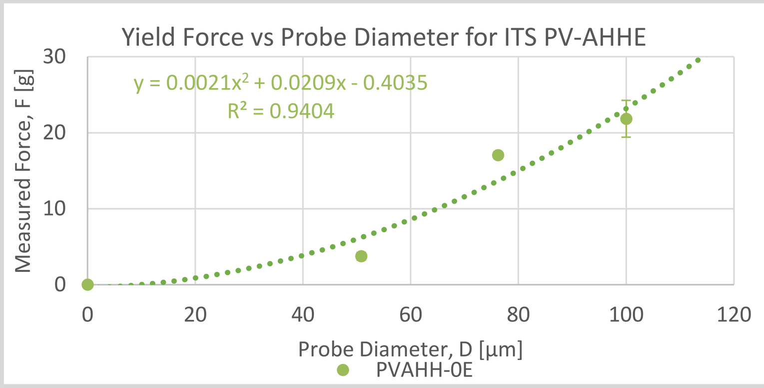
- The compliant nature of ITS materials causes differences in the curves.
- Force vs. OT curves resemble the shape of the stress-strain curve.
- The region between O → A can be approximated as the elastic region.
- Forces between A → B may begin to permanently deform the polymer.

Results

Tip Shaping Materials



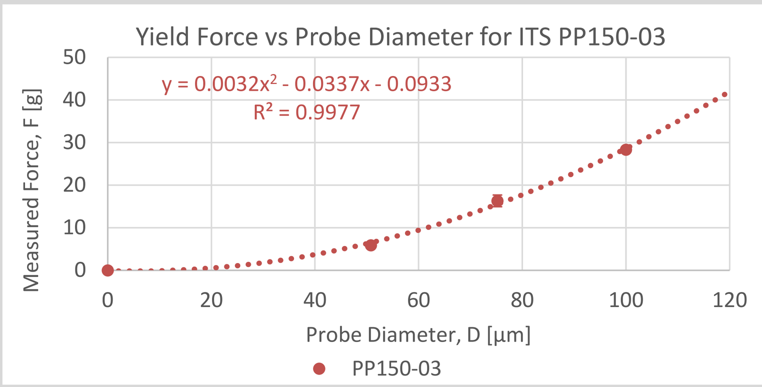


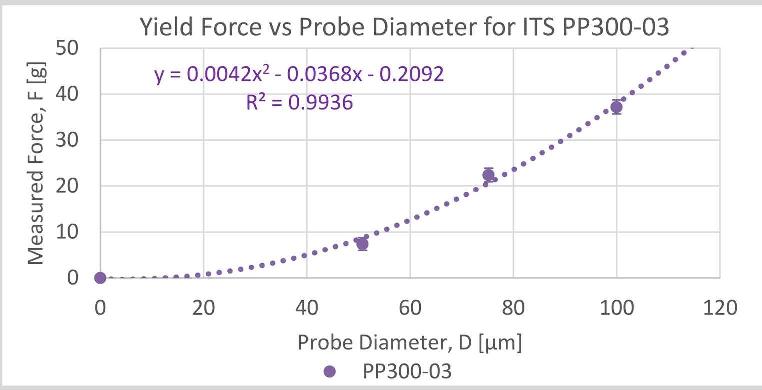


Curve Fits:
Quadratic (2nd order polynomial)

- ITS can generate a model that will predict when a probe punctures the polymer.
- Threshold force curve is shown. Forces above the curve will penetrate polymer.

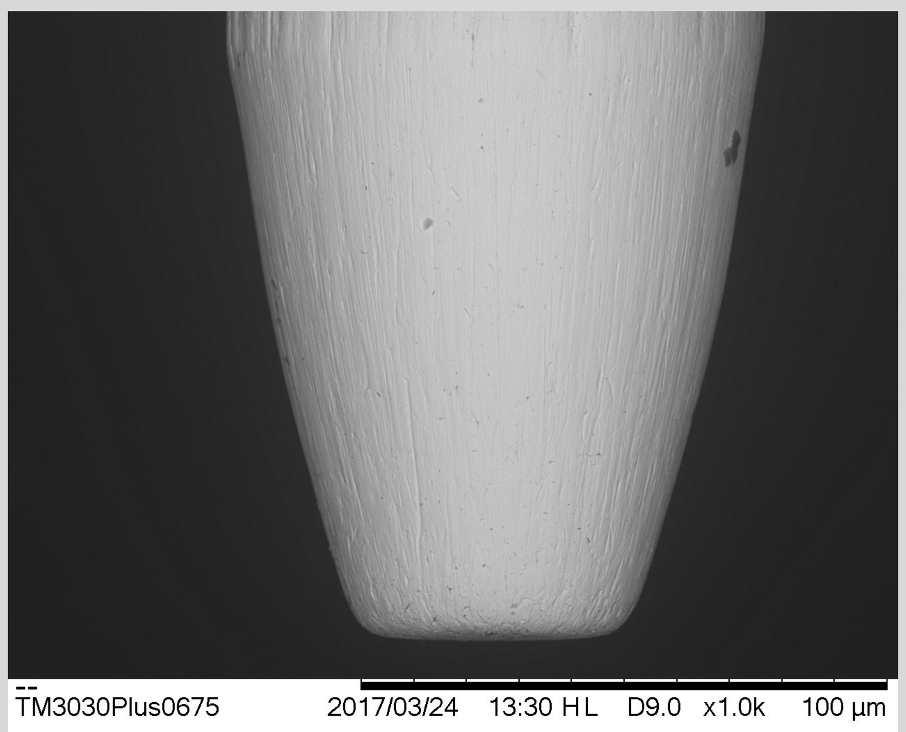
Tip Cleaning Materials

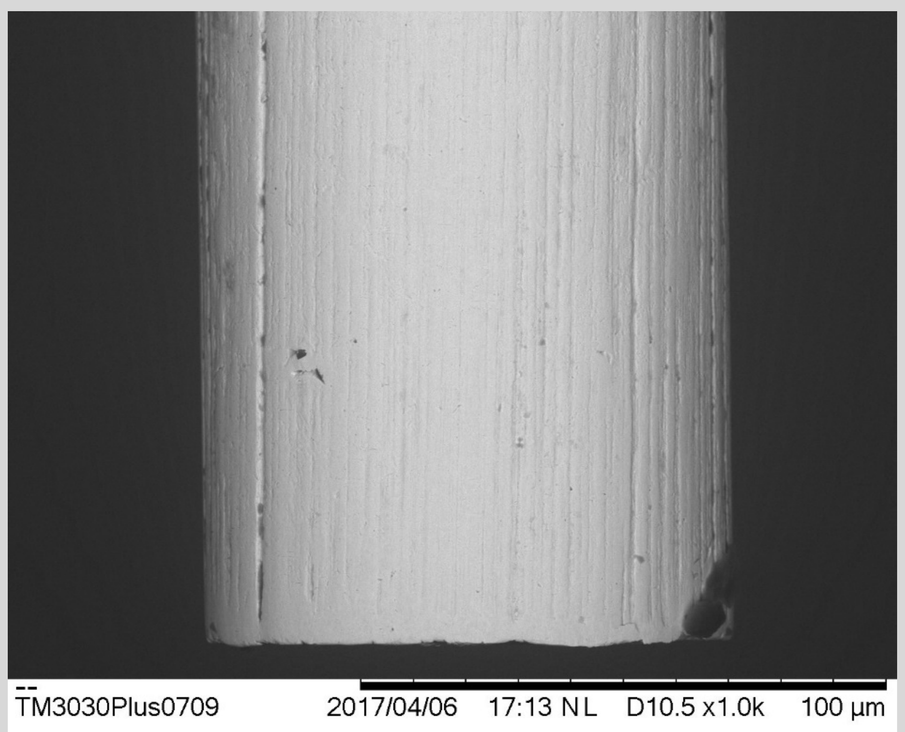


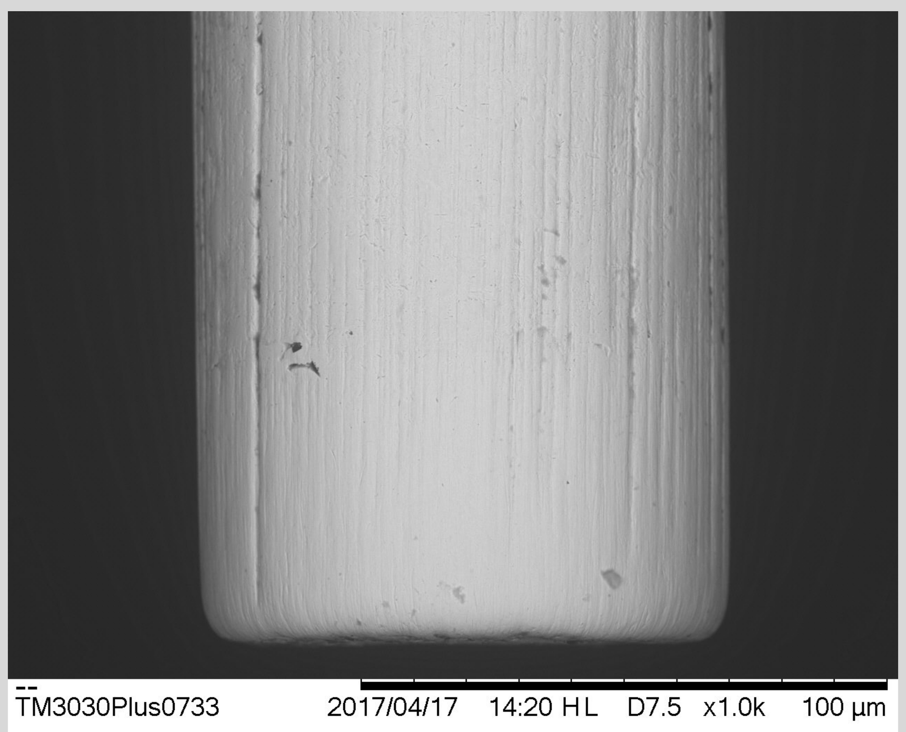


- Tip cleaning materials aim to remain below the line, while shaping is intended to remain above.

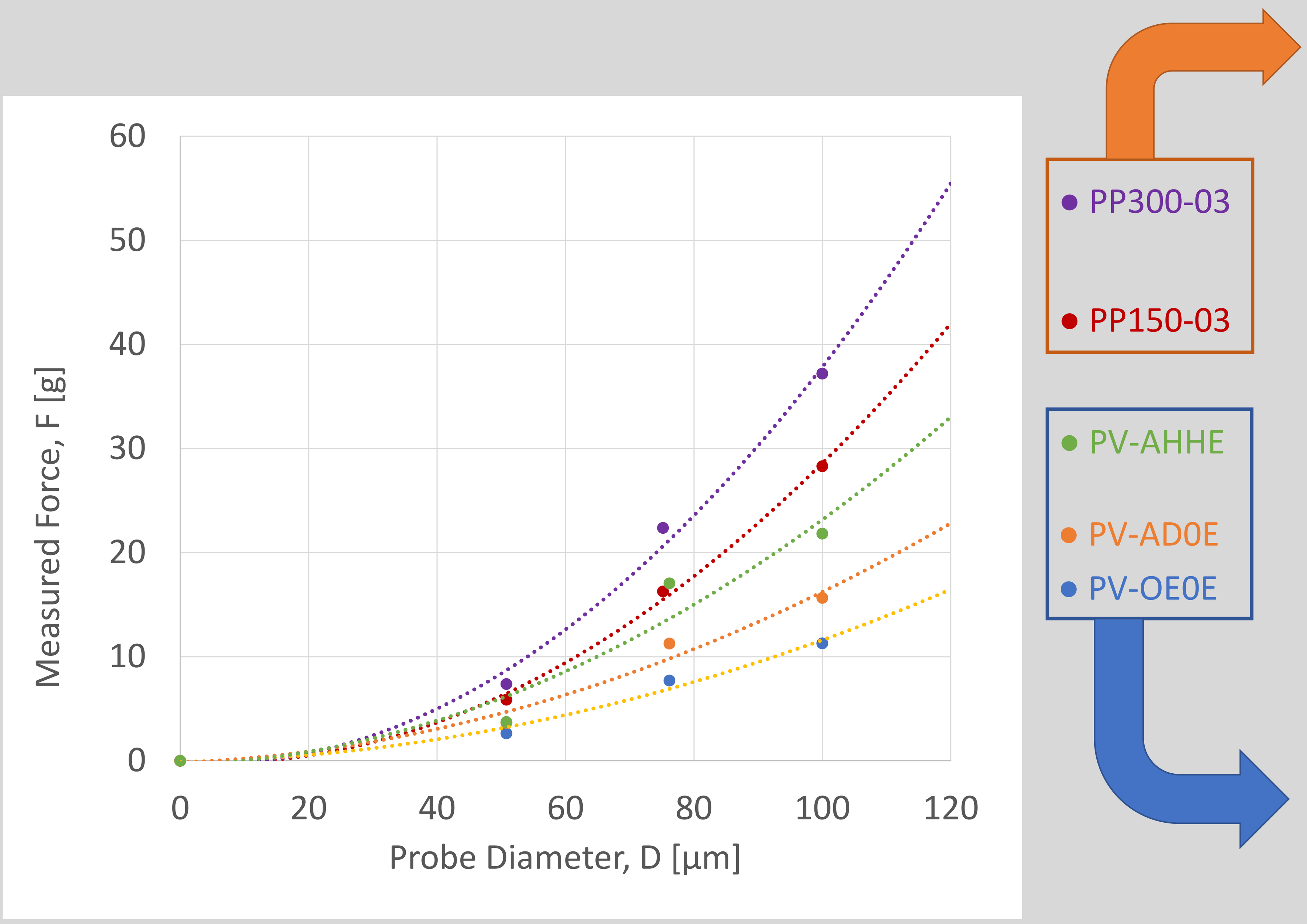
Photos below are taken on 100um diameter vertical probes after 25,000 TDs.







Analysis – Elasticity Considerations



- Probe Polish materials are very elastic and require increased force and over travel to penetrate the surface.
- PP300-03 has more abrasive (increased hardness) causing higher puncture force.

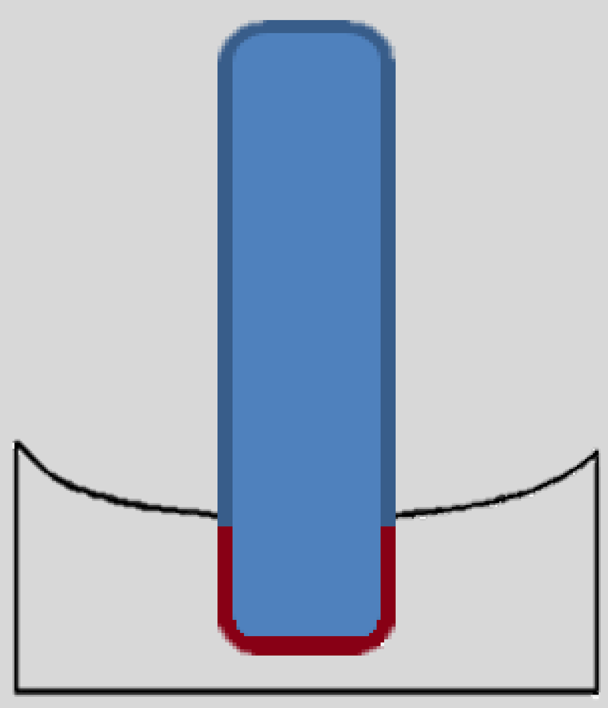
- Probe Vertical materials puncture more easily due to lower elasticity.
- Puncture force increases as material hardness increases.
  - PV-AHHE is the most abrasive of the PV materials.

- As probe diameter decreases, required puncture force decreases.
- This is a function of probe area as shown in mathematical model.

Analysis – Cleaning vs. Shaping

Shaping

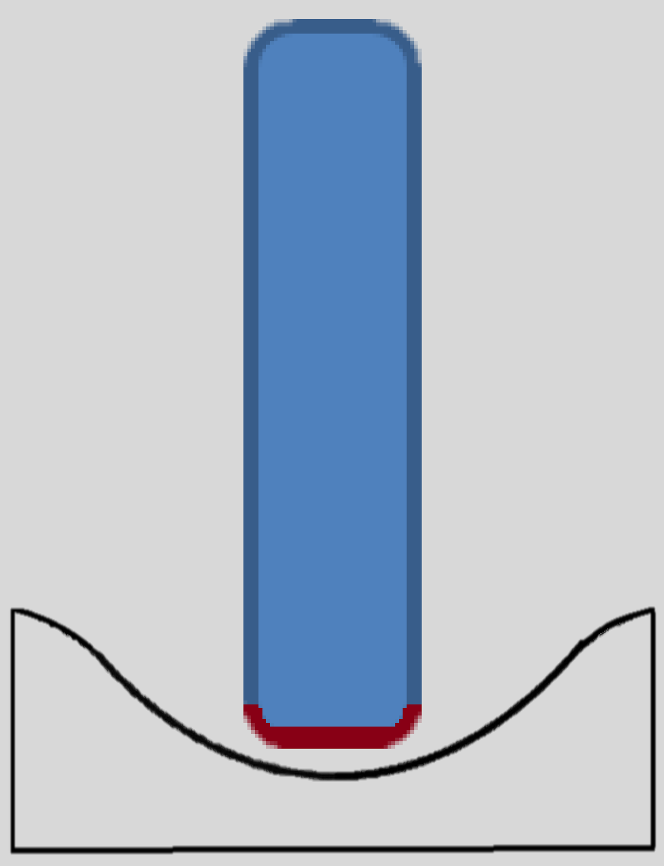
- Shaping occurs when:
  - Probe breaks through surface of polymer.
  - Plastic deformation occurs in the material.
  - Permanent, noticeable indentation in the material.
- Results in sharpening of probe tips.
- Creates a taper along probe length.



Affected area of punctured probe being shaped.

Cleaning

- Cleaning occurs when:
  - Over travel remains within material's elastic limit.
  - Material will rebound to its original shape.
- Results in mild rounding or smoothing of probe tip.



Affected area of probe undergoing cleaning.

Conclusion

- Shaping occurs once the probe punctures the material and causes increased wear and a dramatic taper of the tips.
- Cleaning occurs below threshold force in which puncture occurs.
- A wide range of materials and probe geometries may be used to evaluate the puncture force for tip shaping/cleaning.
- The required puncture force can be predicted for a variety of elastomeric materials.

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