

Cylinder Bore Surface Texture Analysis

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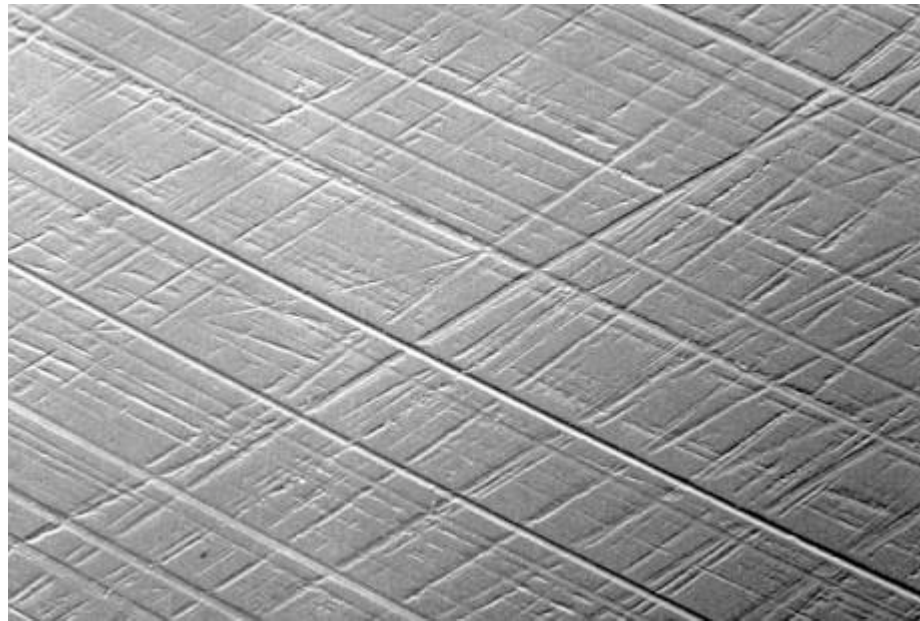
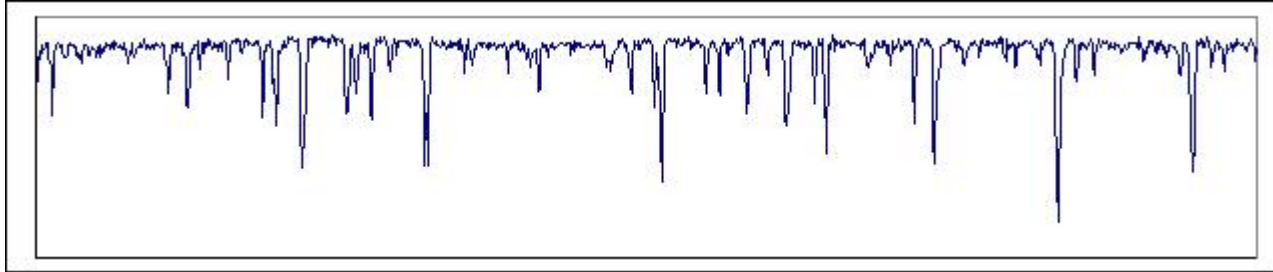
Overview

- **Why is plateau honing important?**
- **How do you measure this?**
 - Instruments, settings (and problems)
- **How do you describe the surface?**
 - Traditional methods
 - Rk parameters
 - Probability Parameters

Cylinder Liners/Bores

- **“Let the engine do it”**
 - **Given a rough surface, the engine will/may plateau itself.**
 - Time, debris, wear of other components
- **Plateau Honing**
 - **Generate a rough surface and remove the high areas in a controlled manner.**

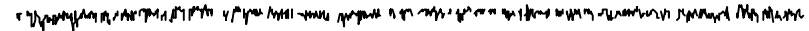
Plateau Honing



Why Plateau Honing?

Generate a surface texture that has the benefits of a smooth surface and the benefits of a rough surface.

Smooth on top



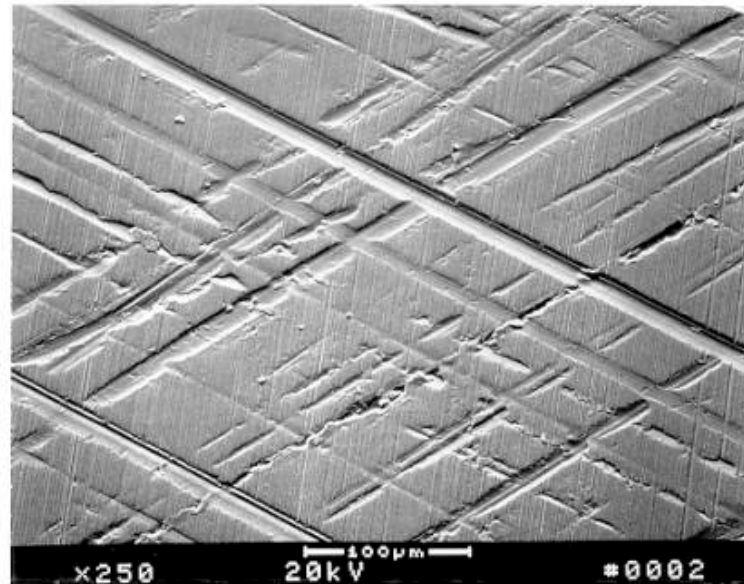
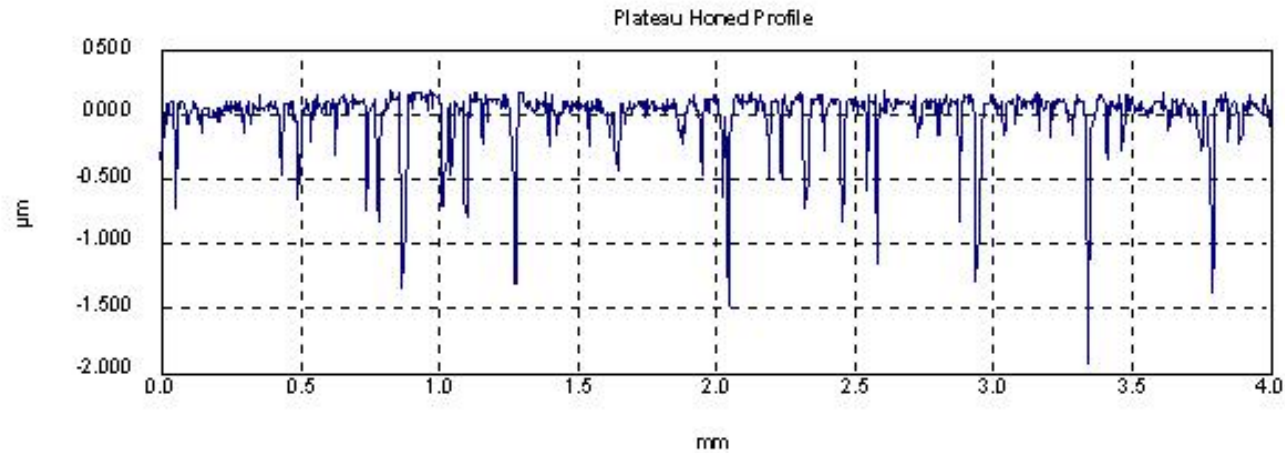
Rough underneath



Surface Functionality

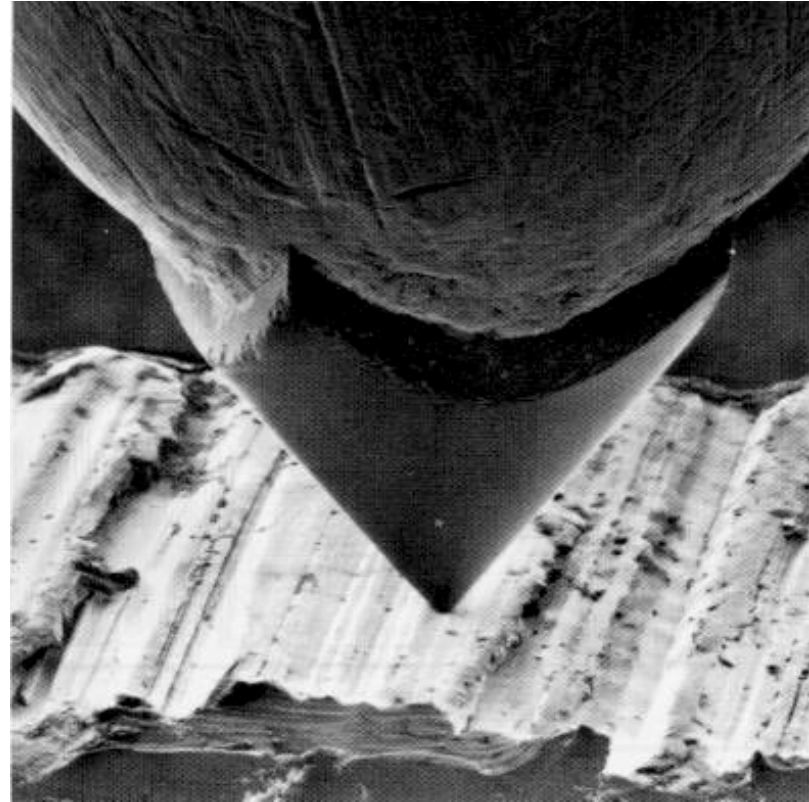
- **Friction? Running clearance?**
 - *Smoother plateau*
- **Wear? Sealing?**
 - *More contact area*
- **Lubrication Retention? Debris Collection?**
 - *Increased valley volume*

A Complete Report (2D + 3D)



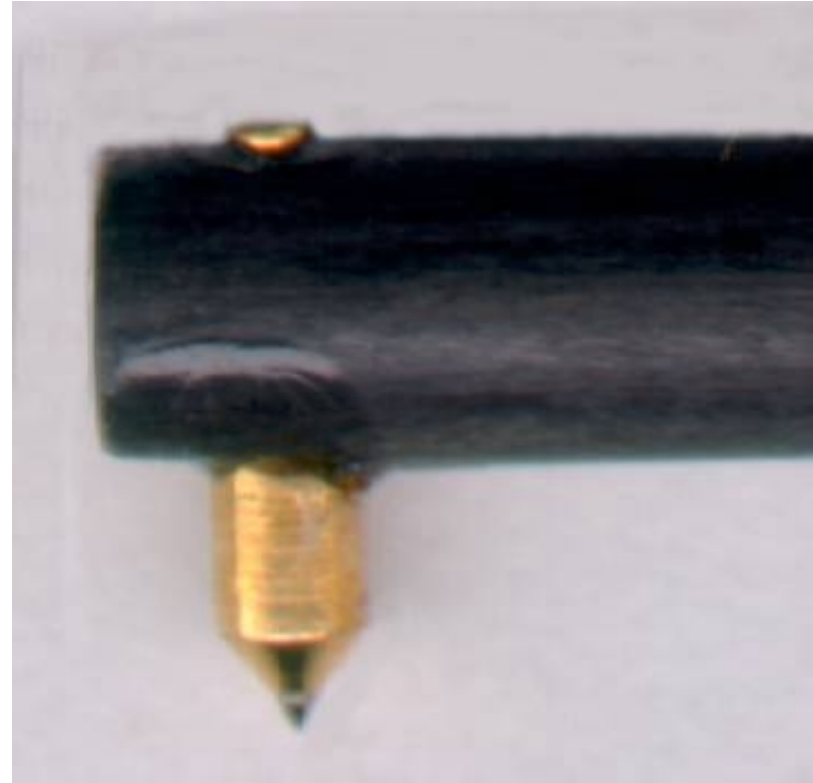
Stylus Based Approaches

- **Two basic means**
 - **Skidless**
 - **Laboratory Style**
 - **Stylus Tip is the only thing that contacts the surface.**
 - **Skidded**
 - **A radiused “skid” rests on the surface and serves as a reference.**



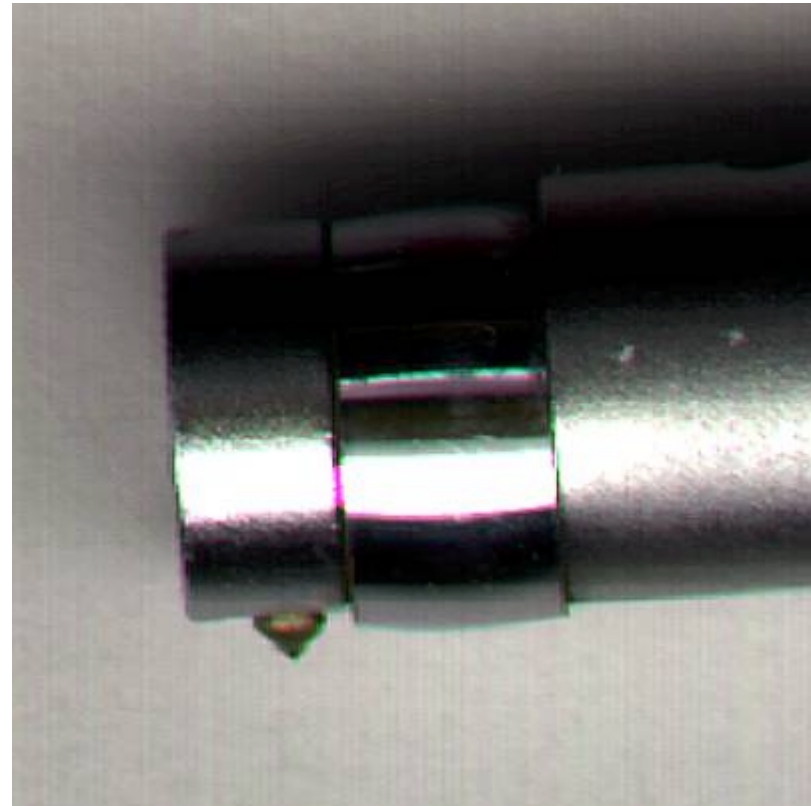
Skidless Measurement

- **Provides “true” picture of surface**
 - Including waviness
- **Alignment is critical**
 - Limited Working Range
- **Sensitive to Vibration**
 - Test by measuring an optical flat.



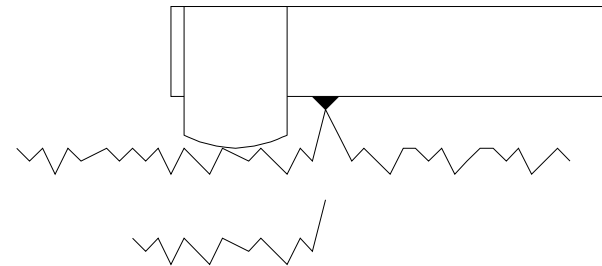
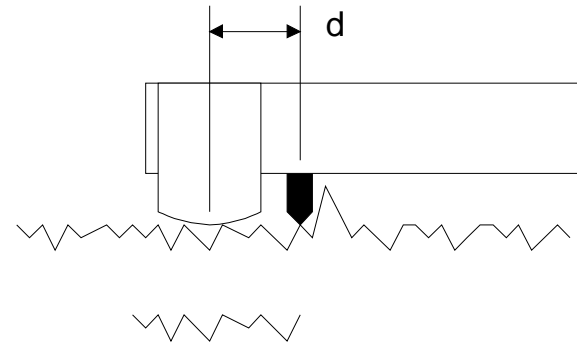
Skidded Measurement

- **The stylus tip moves relative to this skid.**
 - Various skid designs
- **Waviness is hidden.**
 - The skid “follows” waviness.
- **Sensitive to debris**
 - Generating artificial waviness.



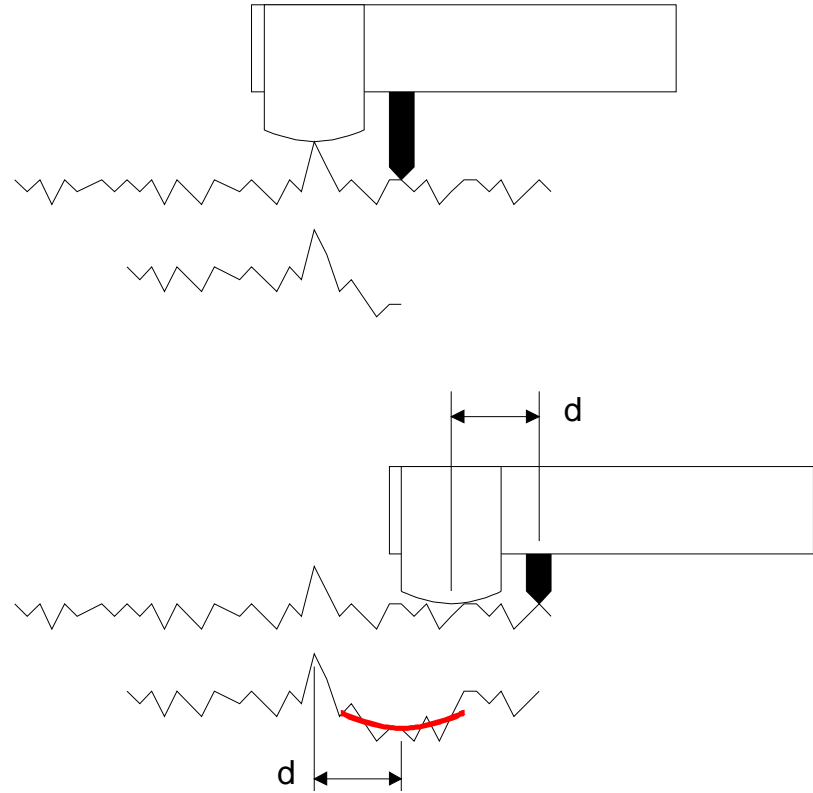
Errors Due to “Trailing-Skid”

- While the skid and stylus are on the same level, the measurement is acceptable.
- When the stylus encounters a peak, it is recorded in the output data set.



Errors Due to “Trailing-Skid”

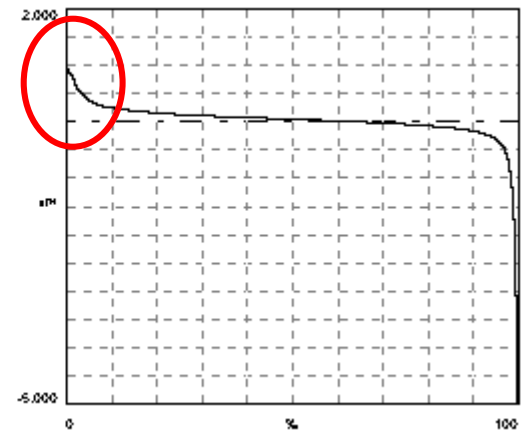
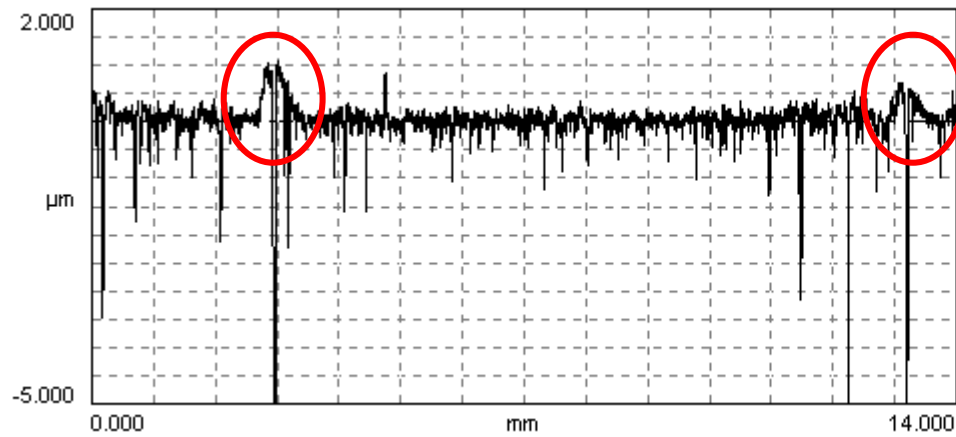
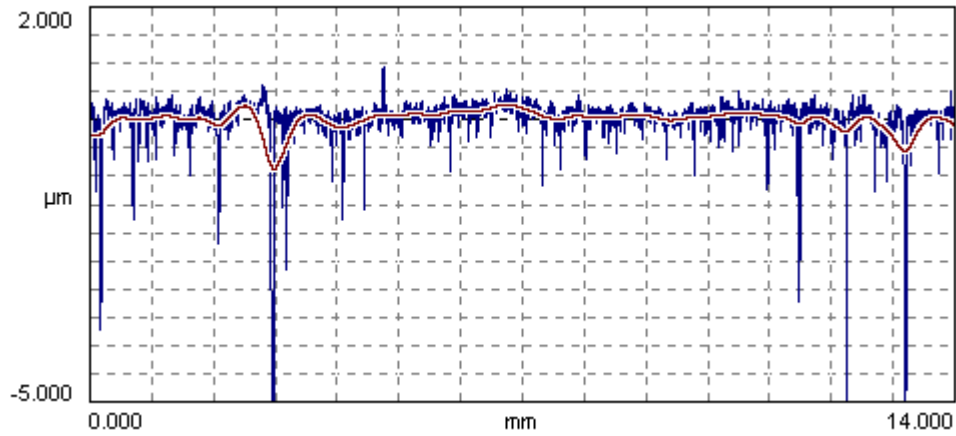
- When the skid encounters a peak, the stylus moves downward.
- The resulting profile has a “depression” based on the skid position and geometry.



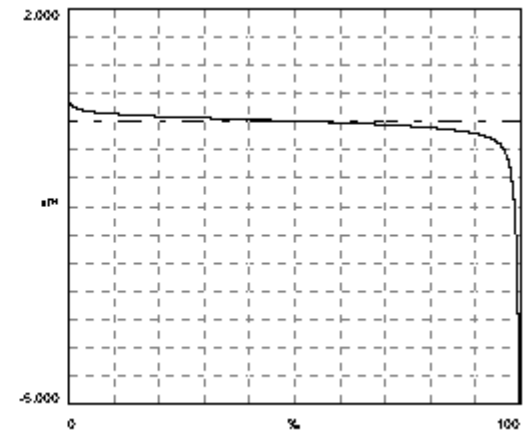
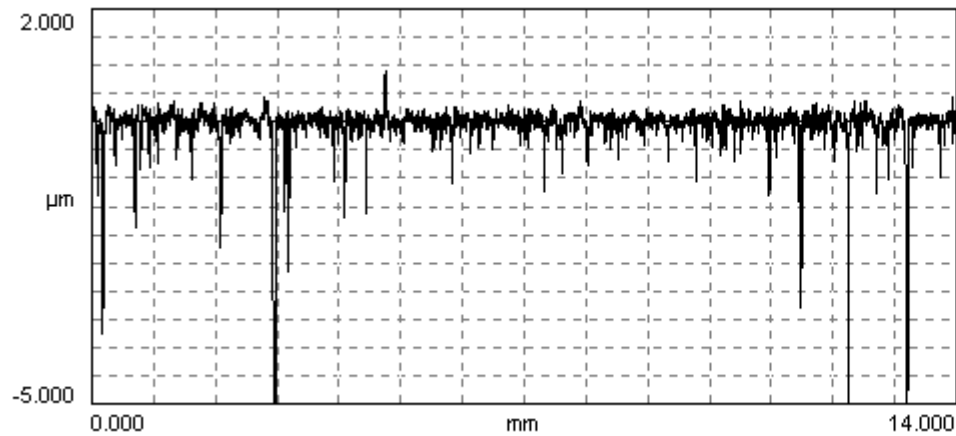
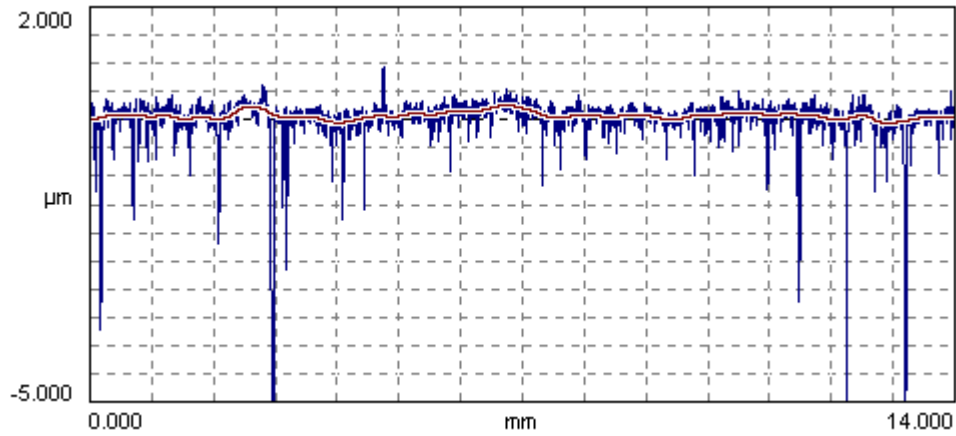
Errors Due to “Trailing-Skid”



Traditional Filtering



Robust Filtering



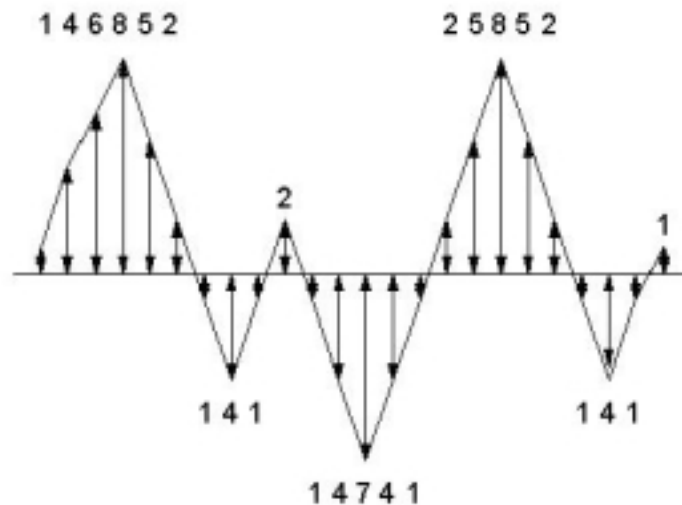
Parameterization Approaches

- **Traditional**
 - Ra, Rz, tp
- **Rk**
 - Rk, Rpk, Rvk, Mr1, Mr2
 - Based on the analysis of the bearing ratio curve.
- **Probability**
 - Rpq, Rvq, Rmq
 - Based on normal probability analysis.

Traditional Parameters

- Ra

The average deviation from the mean line.

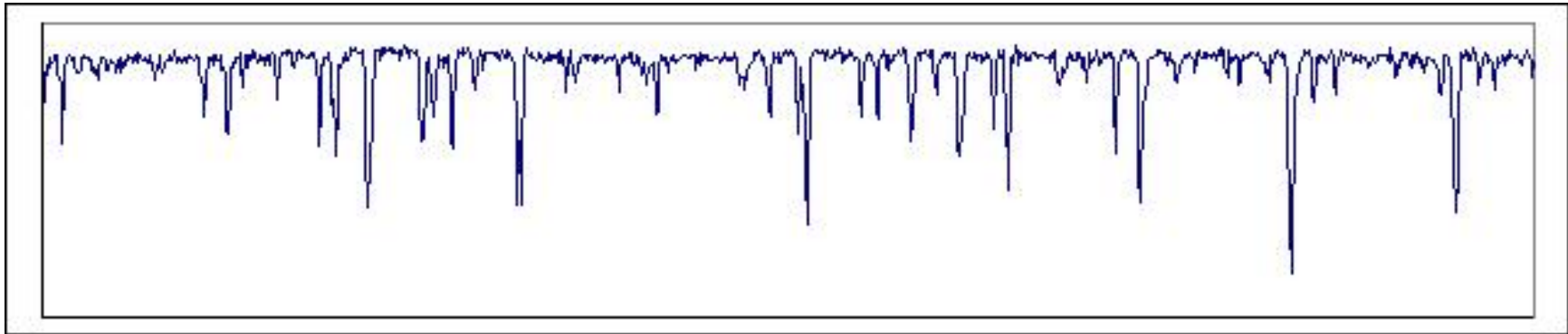


$$Ra = \text{Average}(1, 4, 6, 8, 5, 2, 1, 4, 1, 2, 1, 4, 7, 4, 1, 2, 5, 8, 2, 1, 4, 1, 1)$$

$$Ra = 3.26$$

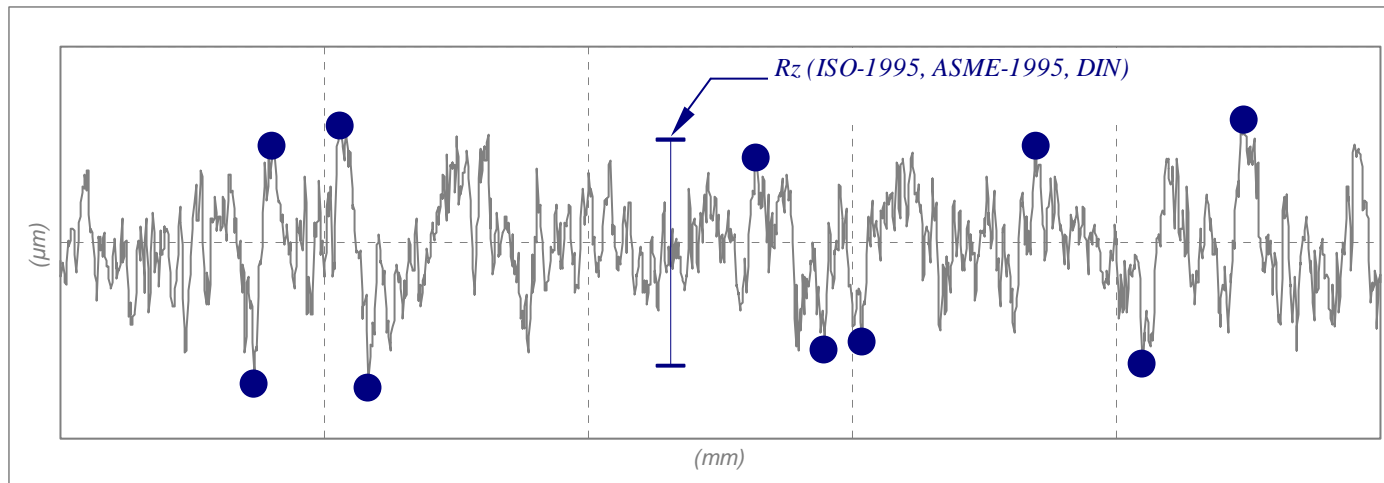
Traditional Parameters

- **Ra in the context of Plateau Honing**
 - Ra tends to be most sensitive to the plateaus of the surface since there are more data points in the plateau.



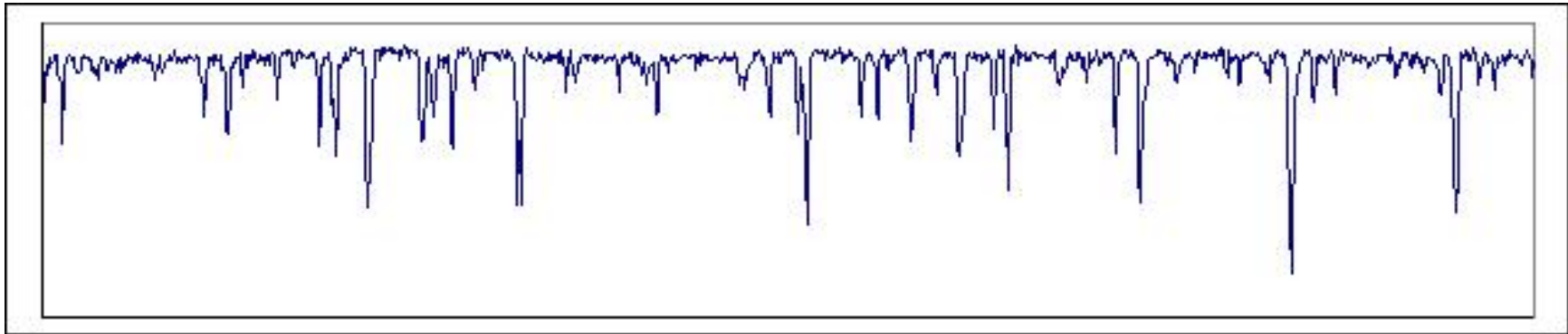
Traditional Parameters

- **Rz**
 - Historically Rz according to DIN (German) standards.
 - Some instruments report this as Rtm.



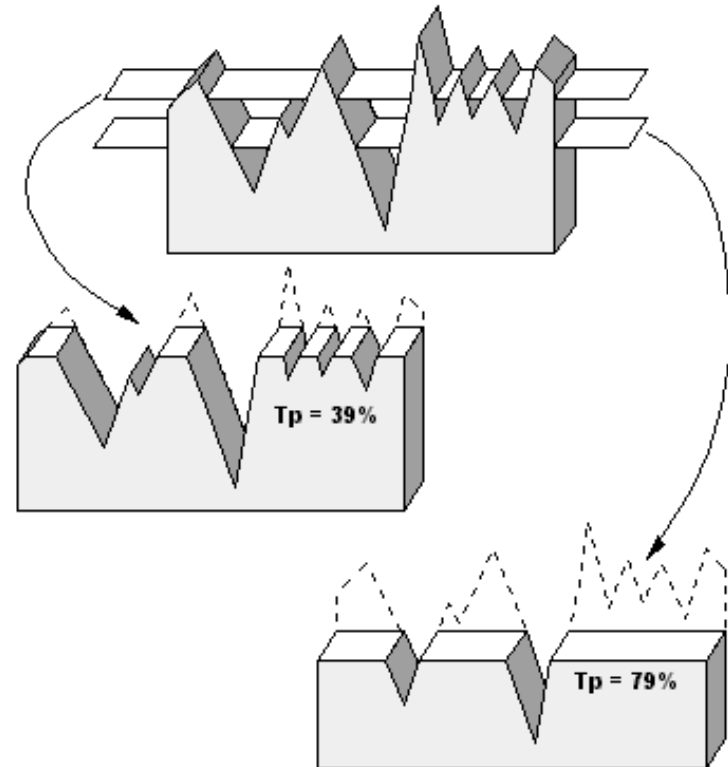
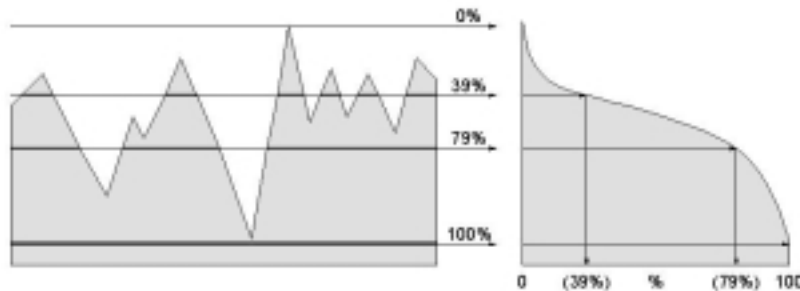
Traditional Parameters

- **Rz in the context of Plateau Honing**
 - Rz tends to be most sensitive to the surface's valleys as they make up most of the peak-to-valley distance.



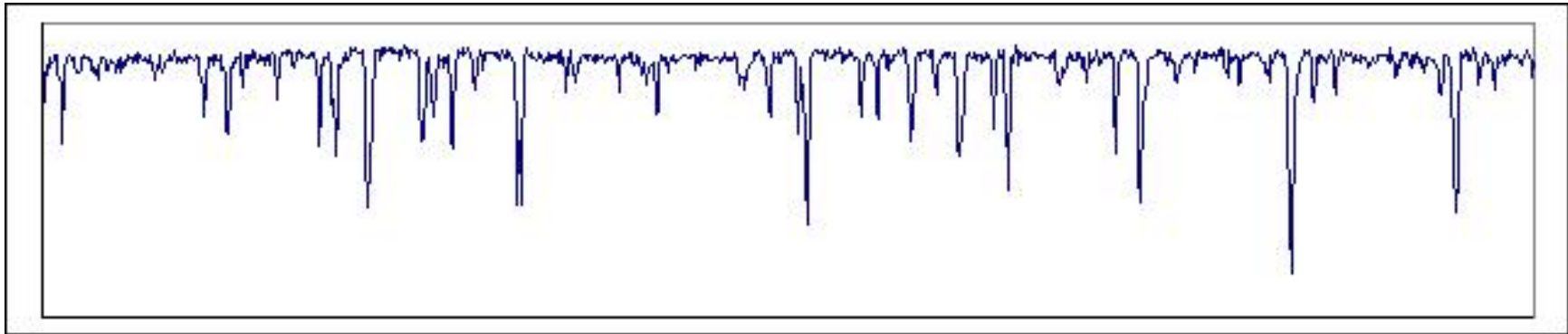
Traditional Parameters

- **tp (Rmr)**
 - At a given depth, the profile is sliced (horizontally) and the material percentage is reported.



Traditional Parameters

- **Rmr in the context Plateau Honing**
 - The depth at which bearing ratio is often placed “just below” the plateau.
 - tp is sensitive to the number and width of the valleys.



Traditional Parameters

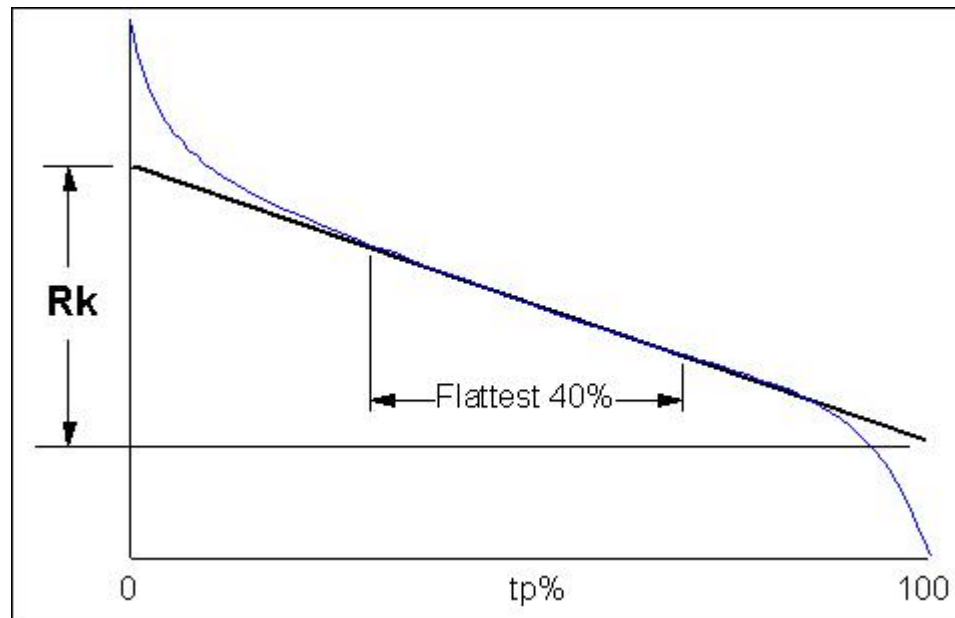
- Ra, Rz and tp are “dependent” parameters
 - It’s very difficult to change just one without affecting the others.
- There is some sensitivity to dirt/debris in Rz and tp (depending on the tp reference).
- Rz can be sensitive to “pull-outs”.
- The Rz:Ra ratio should be considered when trying to control the “shape” of the surface.

Rk Parameters

- Introduced in DIN 4776 (1985)
- Currently standardized in ISO 13565-2
 - Based on describing the bearing ratio curve with line segments.
 - Intended to characterize 3 components of the surface:
 - Core/Kernel (Rk)
 - Peaks (Rpk, Mr1)
 - Valleys (Rvk, Mr2)

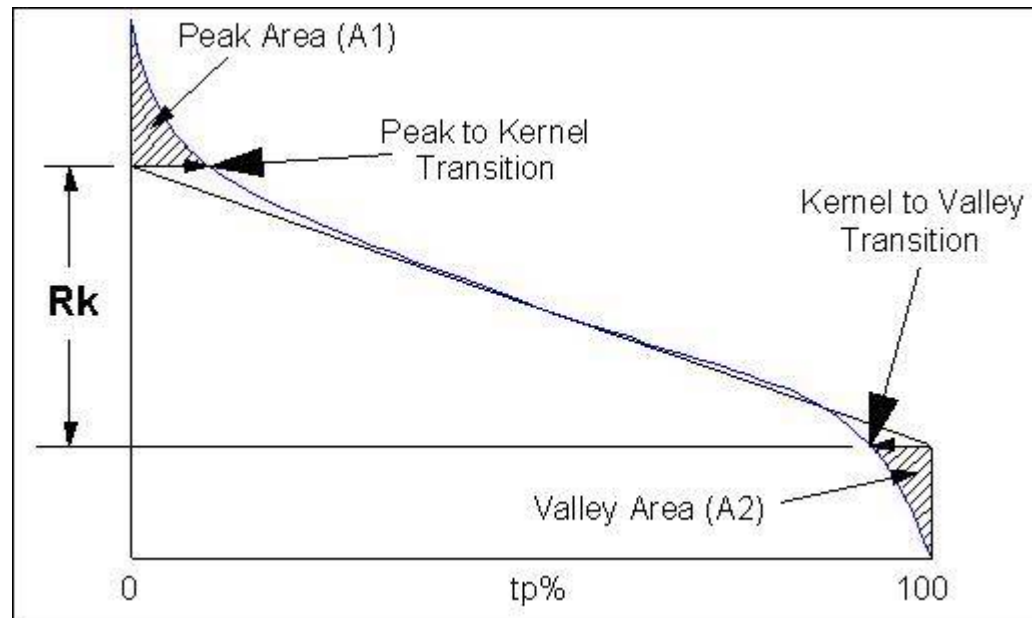
Rk Parameters

- **Step #1: Establish the “Kernel”**
 - Use a 40% window to find the most horizontal region.



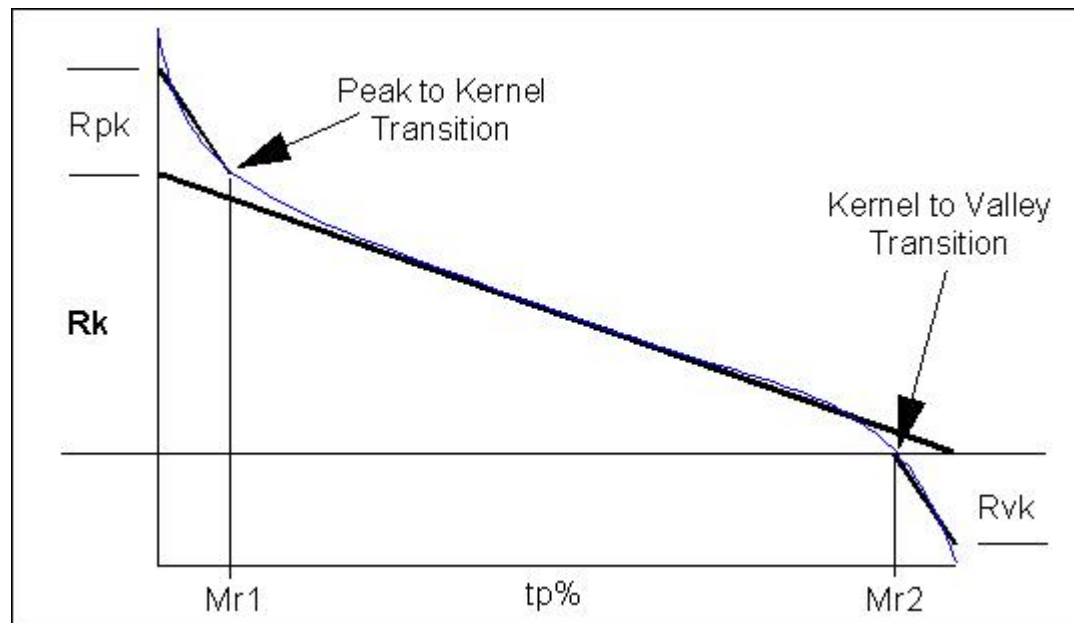
Rk Parameters

- **Step #2: Based on the Rk line, find the “peak” and “valley” transitions.**
 - Mr1 and Mr2



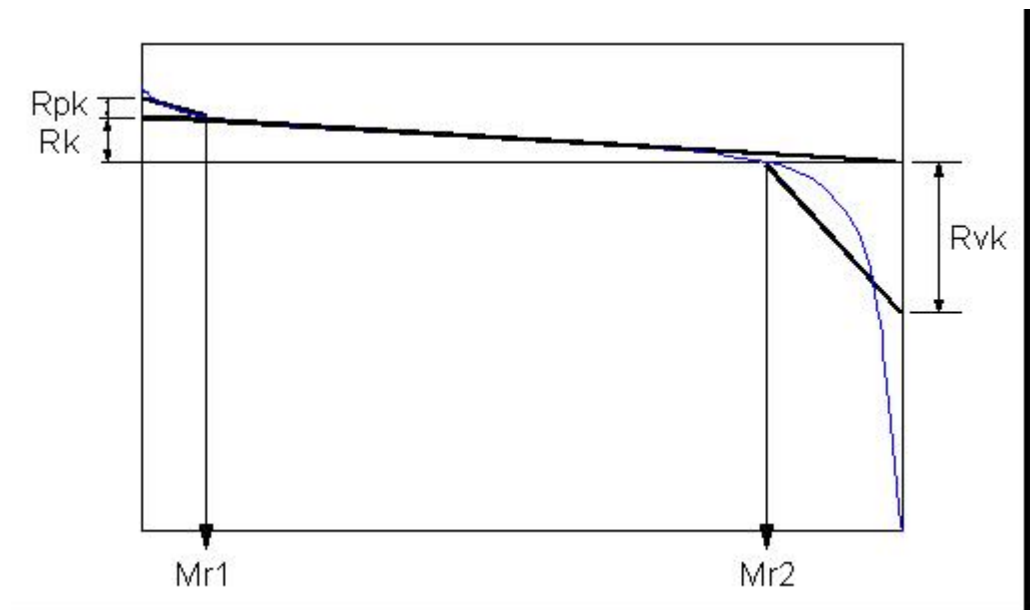
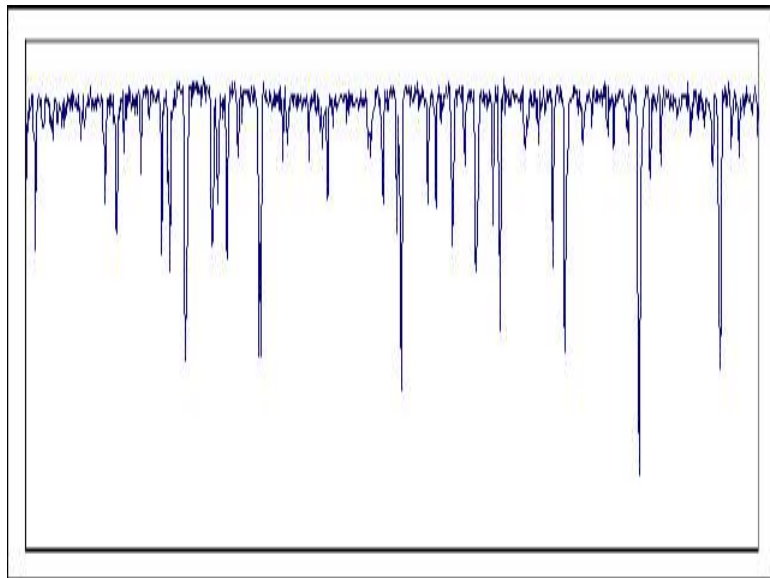
Rk Parameters

- **Step #3: Peak and valley parameters.**
 - Rpk, Rvk = reduced peak and valley “roughnesses”



Application to Plateau Honing

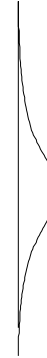
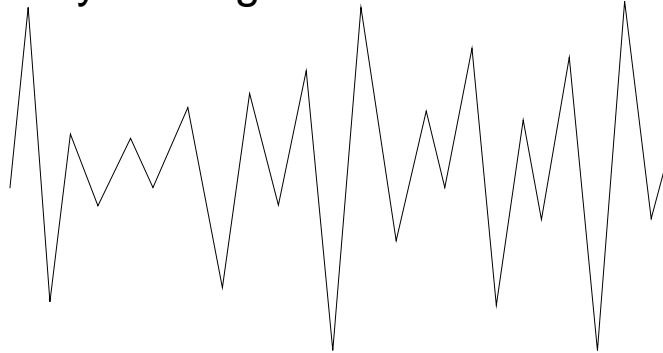
- While serving as an improvement over the “traditional” approach, R_k analysis does not provide a good model of plateau honing. (Particularly in the valley region.)



Probability Model

Combination of two random textures:

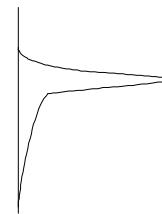
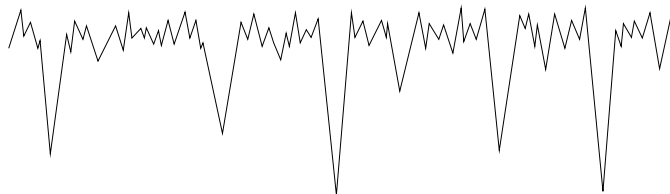
Valley-making Process



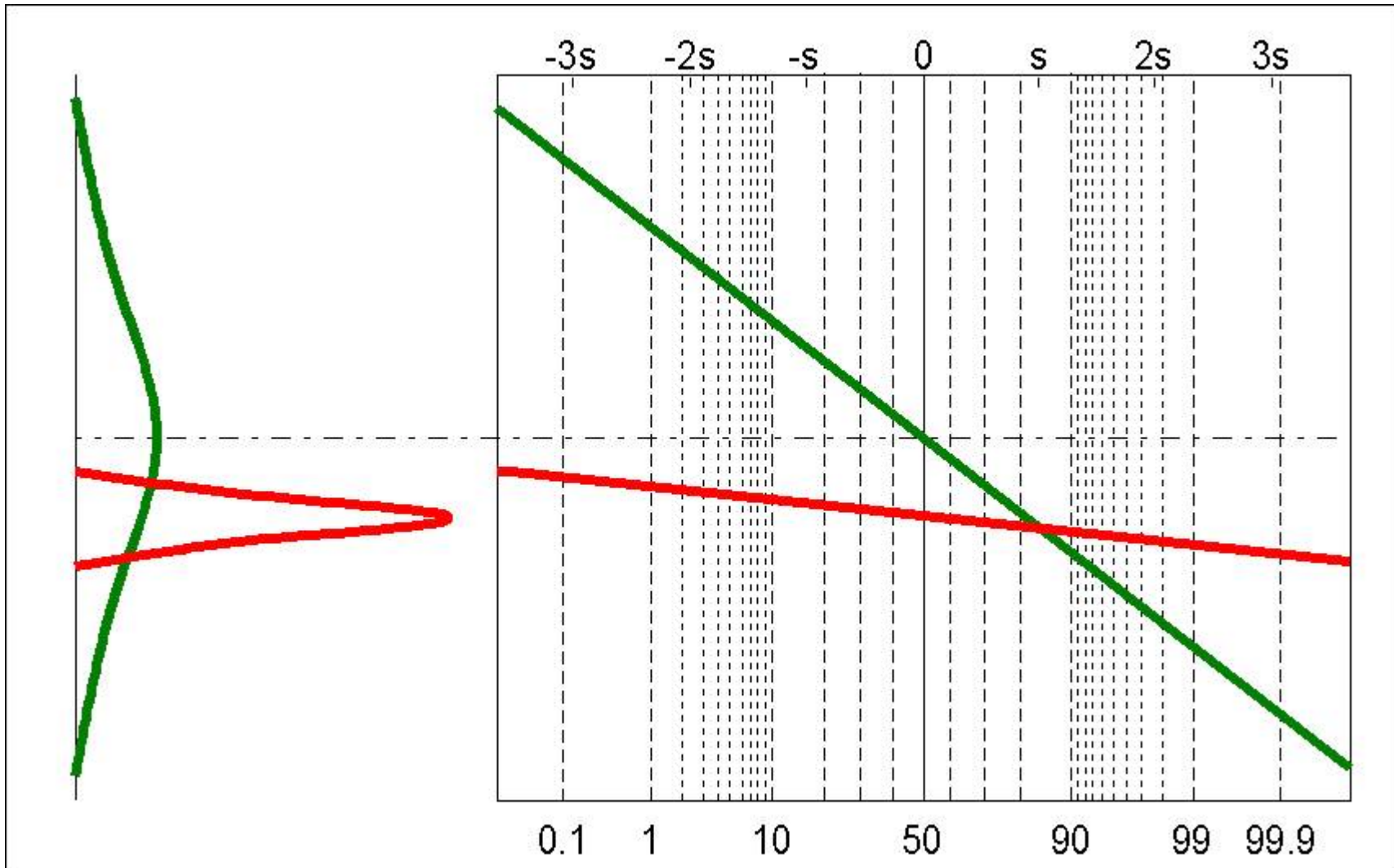
Plateau Process



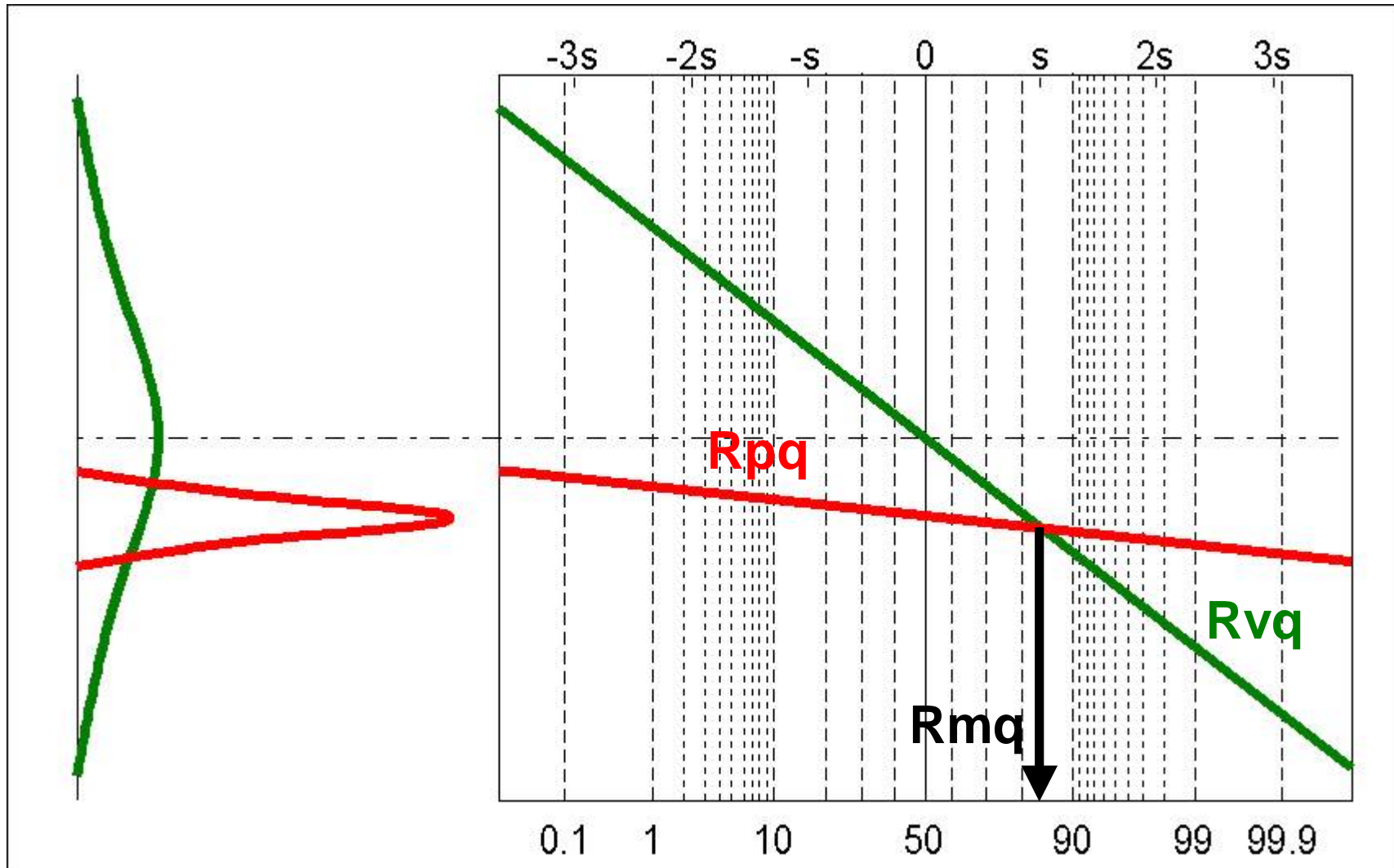
Combination of Processes



Normal Probability Paper

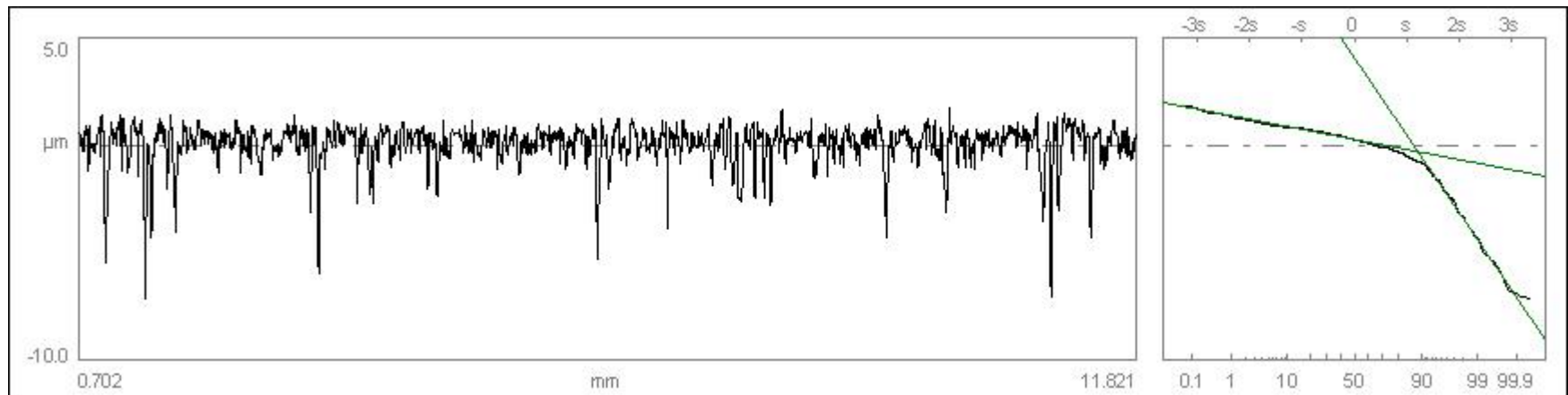


Probability Parameters



Application to Plateau Honing

- This method has been standardized (ISO 13565-3)
 - R_{pq}: Plateau RMS Roughness
 - R_{vq}: Valley RMS Roughness
 - R_{mq}: Plateau-Valley Transition Bearing Ratio



Summary

- **Functionality**
 - Plateau honing continues to be a very important process technology.
- **Measurement Issues:**
 - Measurement ideally consists of a combination between area and profile based measurement.
 - Beware of “shop-floor” (skidded) instruments.
- **Specification Issues:**
 - 3 Basic parameter schemes (and combinations thereof) are commonly standardized and in use.