Surface Finish & Rottler Honing with CBN Stones

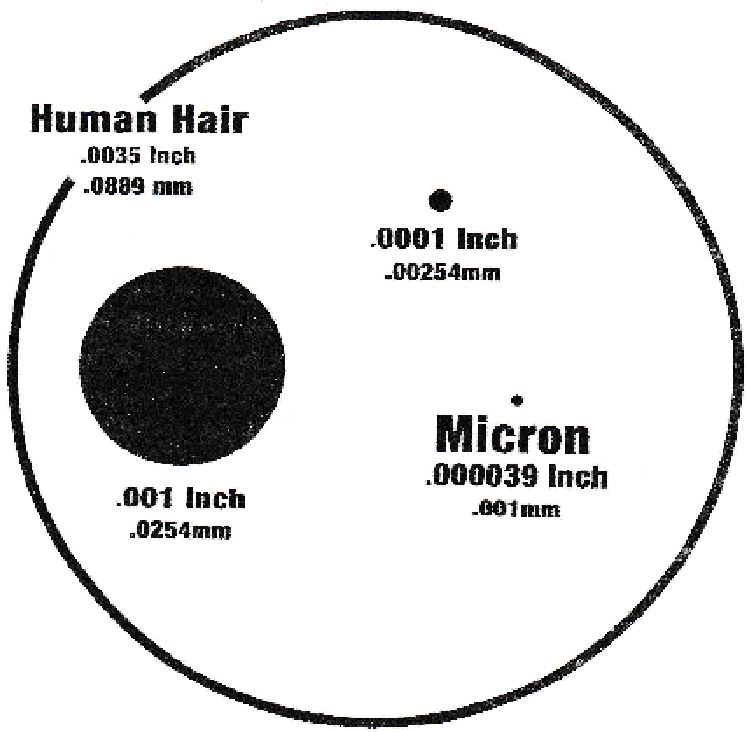
August 31
Presenter: Steve Bauer
Rottler Webinar

Topics

- 1. Measuring Surface Finishes & Plateau
- 2. Cylinder Wall Materials & Their Surface Finishes
- 3. Crosshatch
- 4. What's Changed & What Are We Trying To Achieve?
- 5. Who Invented CBN?
- 6. Pictures of Honed Cast Iron Cylinders
- 7. CBN, Vitrified, & Diamond Stones for Honing

How big is a Micron?

2,000 times size



CROSS
A Cross & Trecker Company

17601 Fourteen Mile Road Fraser, Michigan USA 48026
Telephone: 313 293-3000 FAX: 313 296-4707

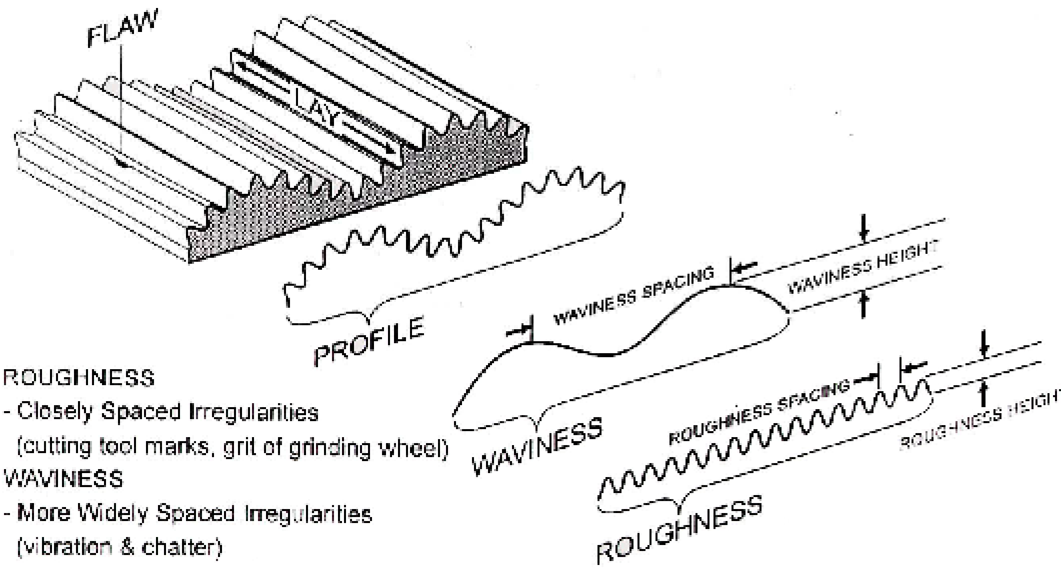
Stone Usage

Stone type	Cast Iron	Aluminum	Steel
Aluminum Oxide *	X		X
Silicon Carbide *	X	X	X
CBN **	X		X
Diamond **	X	X	

* Conventional
** Superabrasives

Measuring Surface Finishes

Basic Components & Elements of Surface Topography



- ROUGHNESS
  - Closely Spaced Irregularities (cutting tool marks, grit of grinding wheel)
- WAVINESS
  - More Widely Spaced Irregularities (vibration & chatter)
- ERROR OF FORM
  - Long Period or Non-cyclic Deviations (errors in ways or spindles, uneven wear)

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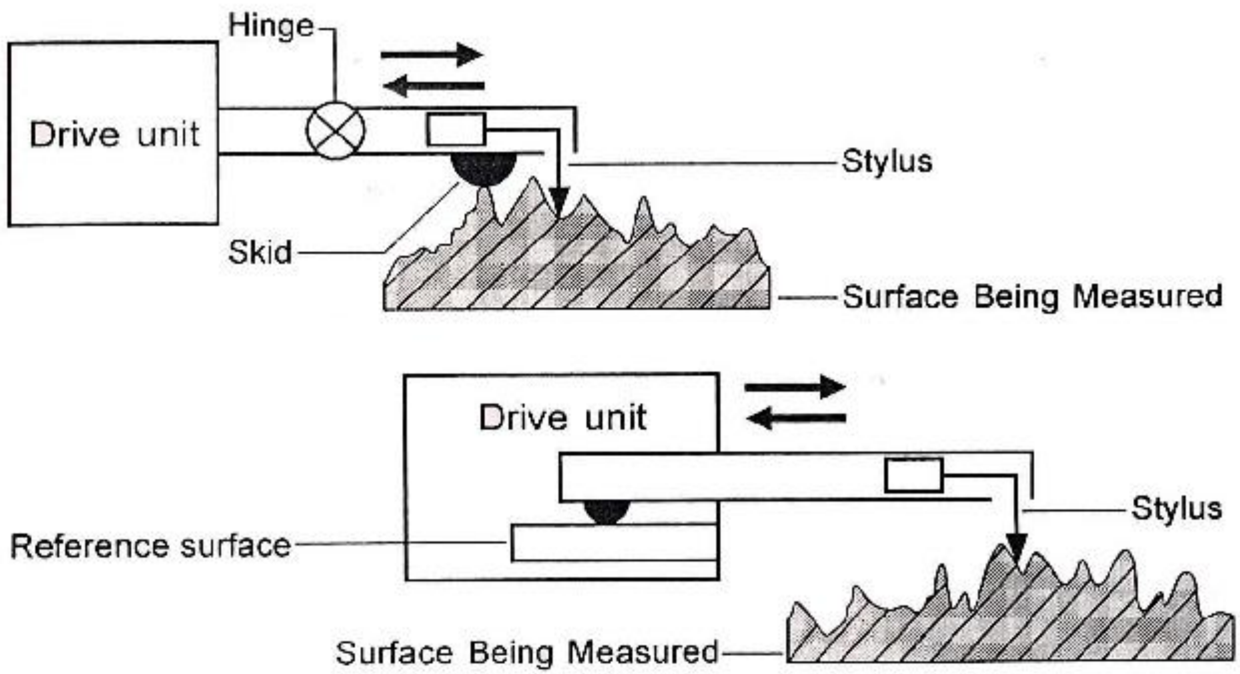
Skid and Skidless Measuring Equipment



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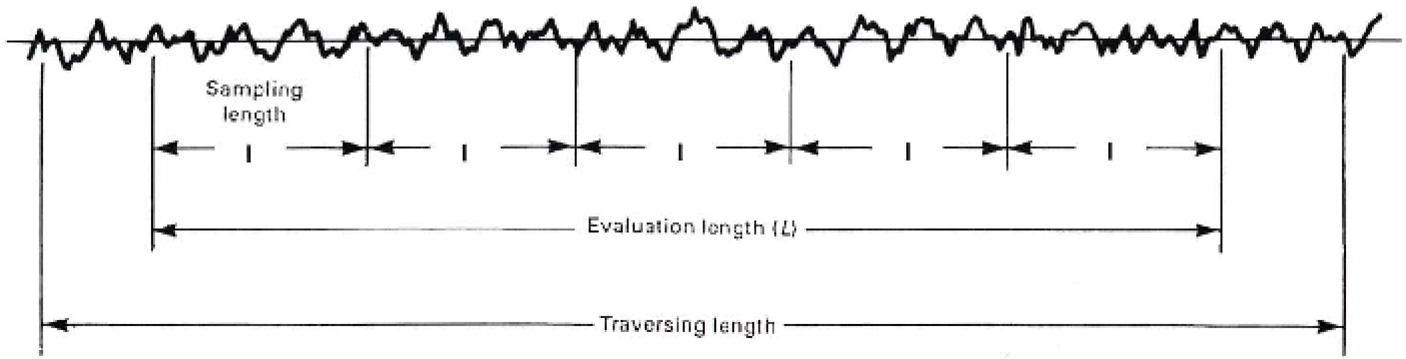
Surface Profile Measurement Lengths



- Sampling Length (l)
- Assessment (Evaluation) Length (L)
- Traversing Length

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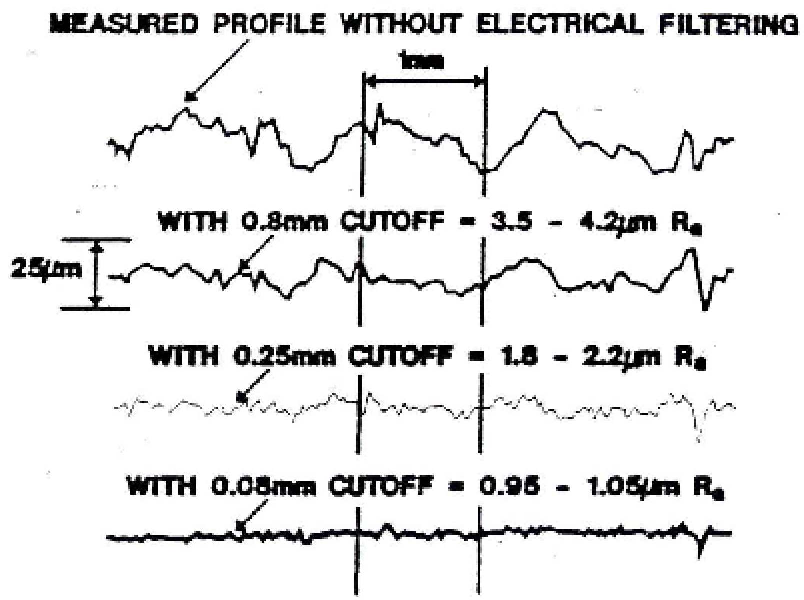
Cutoff Selection Effect on Surface Finish Measurement



NOTE: PROFILES ARE DISTORTED BY UNEQUAL VERTICAL VS. HORIZONTAL MAGNIFICATION.

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R_a – Roughness Average

Advantages

- The most commonly used parameter to monitor a production process.
- Default parameter on a drawing if not otherwise specified.
- Available even in the least sophisticated instruments.
- Statistically a very stable, repeatable parameter.
- Good for random type surfaces, such as grinding.
- A good parameter where a process is under control and where the conditions are always the same, e.g. cutting tips, speeds, feeds, cutting fluid (lubricant).

Disadvantages

- Not a good discriminator for different types of surfaces (no distinction is made between peaks and valleys).
- Not very informative on surfaces with R_{sk} outside ± 2.
- Not a good measure of sealed surfaces.

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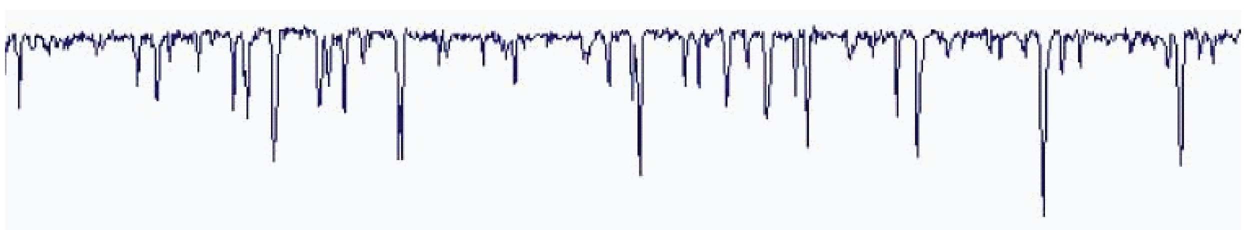
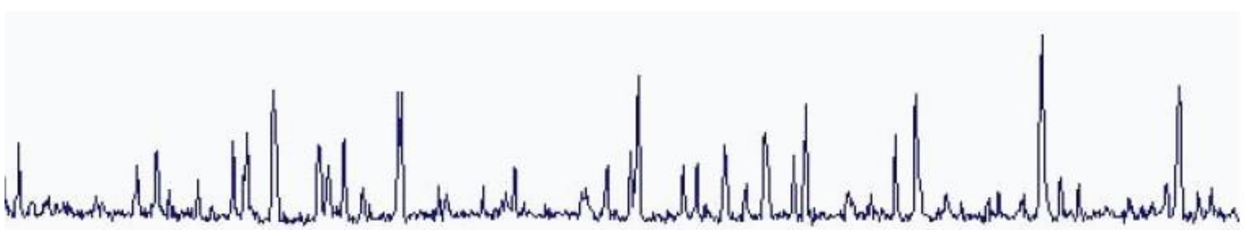
Roughness Average

- Ra averages the peak and valley displacement from a mean line but provides no information about the height of the peaks and the depth of the valleys or the ability of the material to bear a load. Two different surfaces may have a similar Ra yet have two functionally different characteristics.

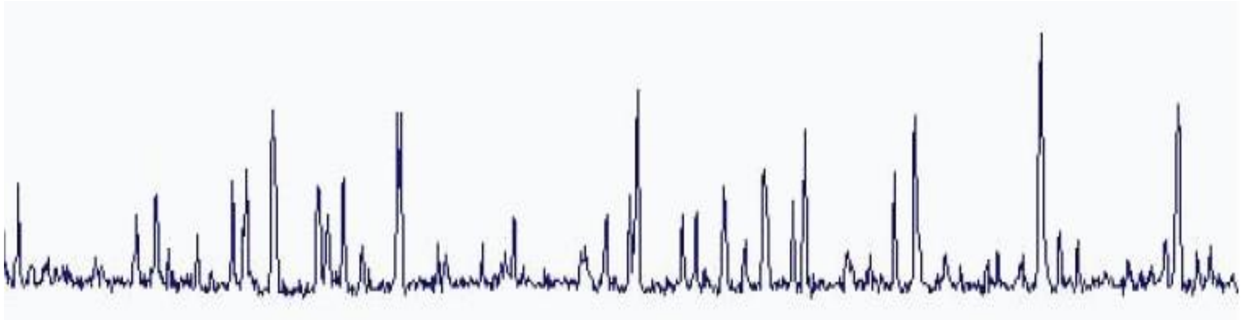
Ra 20



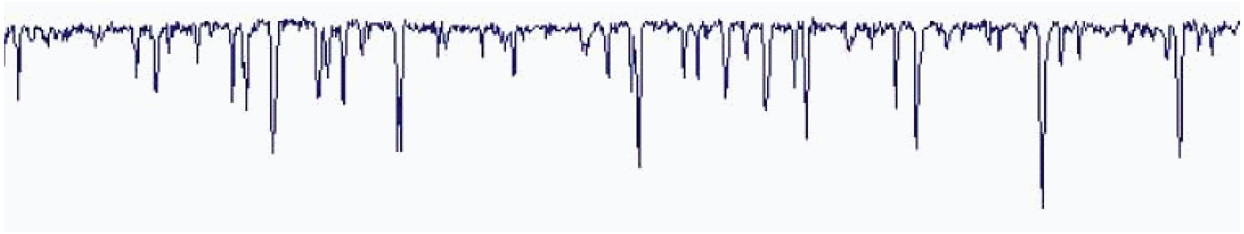
Ra 20



Rpk



Rvk



QUESTIONS NOW

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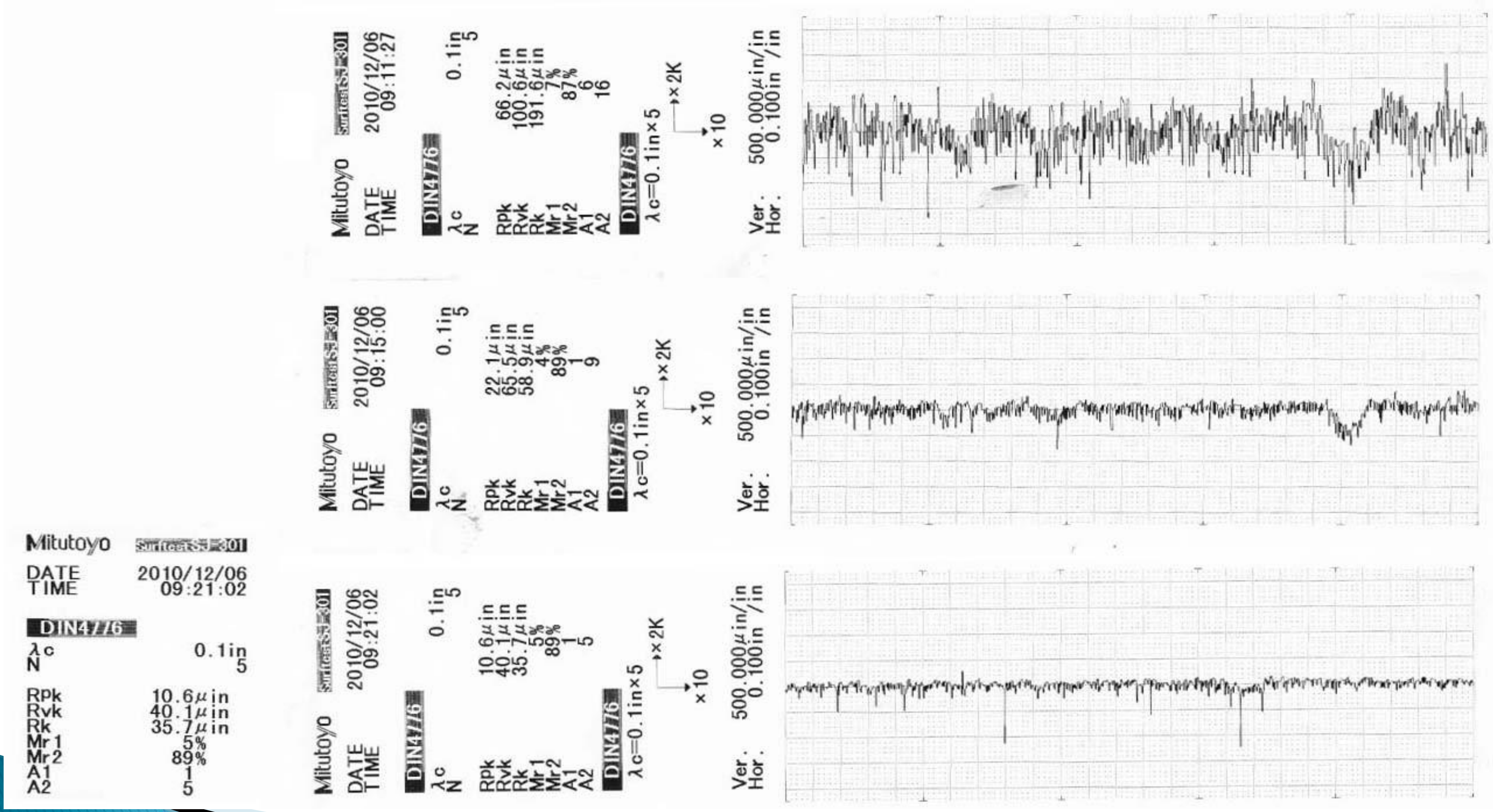
Plateau Finish

220 Silicone Carbide + 4 Strokes 400 Silicone Carbide + 4 Strokes Brush

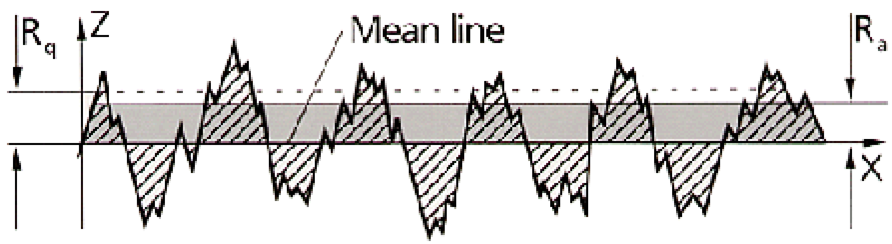


Ra, Rq Parameters

- Roughness average R_a is the arithmetic average of the absolute values of the roughness profile ordinates.

$$R_a = \frac{1}{l}\int_0^l |Z(x)|\, dx$$

- Root mean square (RMS) roughness R_q is the root mean square average of the roughness profile ordinates.



$$R_q = \sqrt{\frac{1}{l}\int_0^l Z^2(x)\, dx}$$

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Old to New Specifications

- Root Mean Square (RMS) is an old specification

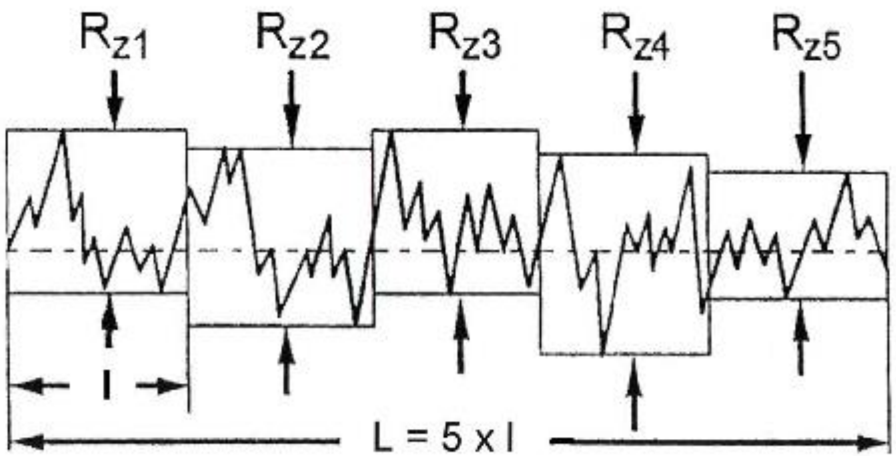
- RMS readings are about 15% higher than Ra readings

R_z, R_{max} Parameter

The Mean Roughness Depth R_z is the mean of five roughness depths of five successive sample lengths l of the roughness

$$R_z = 1/5\ (R_{z1} + R_{z2} + R_{z3} + R_{z4} + R_{z5})$$

The Maximum Roughness Depth R_{max} is the largest of five roughness depths.



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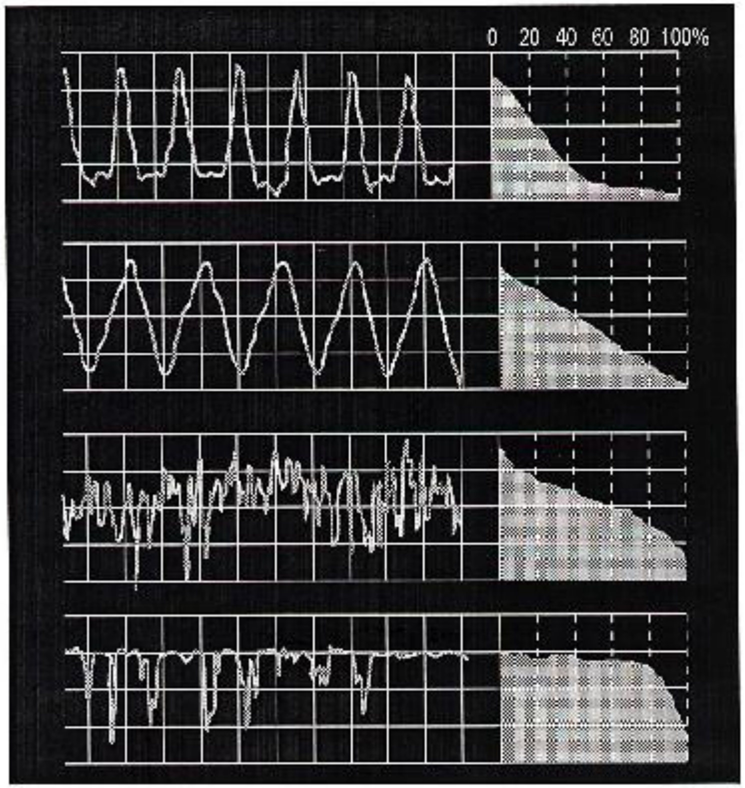
R_z – Mean Peak-to-Valley Height
R_{max} – Maximum Peak-to-Valley Height

Applications

- R_z is more sensitive than Ra to changes in surface finish as maximum profile heights and not averages are being examined.
- R_{max} is useful for surfaces where a single defect is not permissible, e.g. a seal with a single scratch.
- R_z and R_{max} are used together to monitor the variations of surface finish in a production process. Similar values of R_z and R_{max} indicate a consistent surface finish, while a significant difference indicates a surface defect in an otherwise consistent surface.

Bearing Area Curve (BAC)



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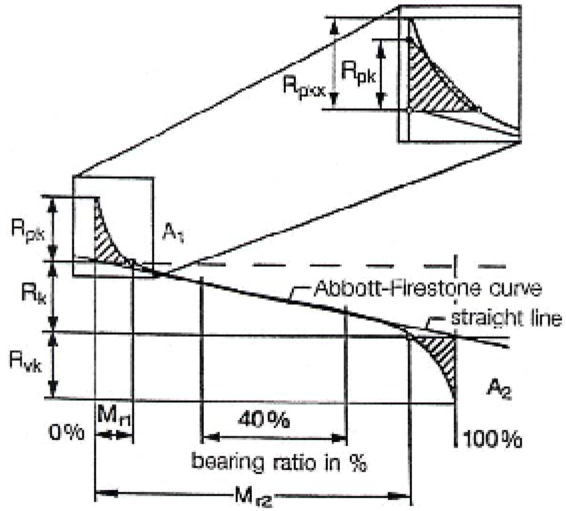
R_k Family of Parameters



A_1	Material filled profile peak area
A_2	Lubricant filled profile valley area
R_k	Core roughness depth
R_{pk}	Reduced peak height
R_{vk}	Reduced valley depth
M_{r1}	Material component relative to peaks
M_{r2}	Material component relative to valleys
R_{pkx} (R_{pk}*)	Total Peak Height
R_{vkx} (R_{vk}*)	Total Valley Depth

<u>Applications</u>

- Multiprocessed, multipurpose surfaces, such as plateau honed
- Sintered, porous surfaces

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Surface Finish Conversions

- Microinch (µ”) to Micrometer (µm)
- Microinch ÷ 40 = Micrometer
- Example:
- Roughness average (Ra) of 10µ” = .25µm

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QUESTIONS

Cylinder Wall Materials & Their Surface Finishes

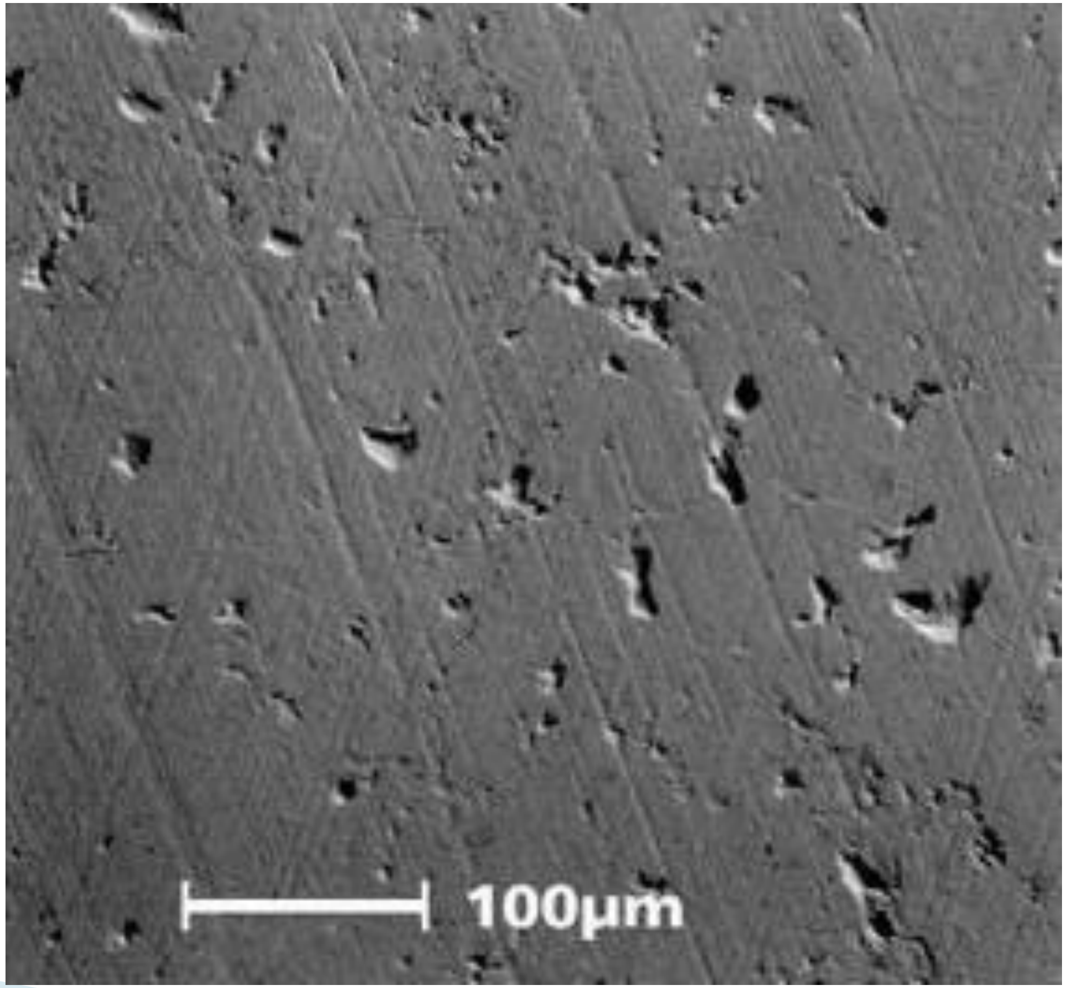
Air Plasma Spray(APS) Coatings after Honing

SUMEBore by Oerlikon Metco

SUMEBore

- It reveals one of the main characteristics of this type of coatings – the porosity –which retains the oil in the surface.
- Porosity is the reason why the surface can be honed to a mirror finish and would not scuff, like a polished cast iron bore.
- A honed plasma surface can be seen in Figure 5 in the scanning electron microscope (SEM).

Honed Surface with Open Porosity SUMEBore   Figure 5



SUMEBore

- It is important to do the honing in such a way that the pores are properly opened and that they do not contain any debris from the honing process.
- Figure 6 shows the mirror finished surface of a 200mm cylinder liner.

Mirror Finish in SUMEBore Figure 6

Surface finish specification for Air Plasma Spray(APS) Coatings after Honing; SUMEBore

- Ra 0.15–0.35 μm = 6–14μin
- Rz $<5\mu$m = $<$ 200μin
- Rk $<0.3\mu$m = $<$ 12μin
- Rpk 0.07–0.16μm = 2.8–6.4μin
- Rvk 0.5–2.0μm = 20–80μin

Surface finish specifications of Cast Iron after Honing

- **Total Seal**

- Street/ Strip & weekend Circle Track
  - Rpk 10–15, Rk 35–40, Rvk 40–45
- Pro Stock, NASCAR, Comp Eliminator & High end Circle Track
  - Rpk 8–12, Rk 18–22, Rvk 28–32
- High Cylinder Pressures
  - Rpk 12–18, Rk 45–50, Rvk 50–60

Surface finish specifications of Cast Iron after Honing

- **Mahle**

- All Rings; Ra 10-20, Rk 25-50, Rpk 10-20, Rvk 30-60

MAHLE
Driven by performance

Surface finish specifications of Cast Iron after Honing

- **Hastings**

- Good Performance; Rpk 8-12, Rk 25-35, Rvk 40-50, Ra 15-20 (12-23 Allowable)

- Pro-Stock & NASCAR: Rpk: 3-5 Rk:12-18 Rvk: 20-25

Old Ways of Breaking in Piston Rings

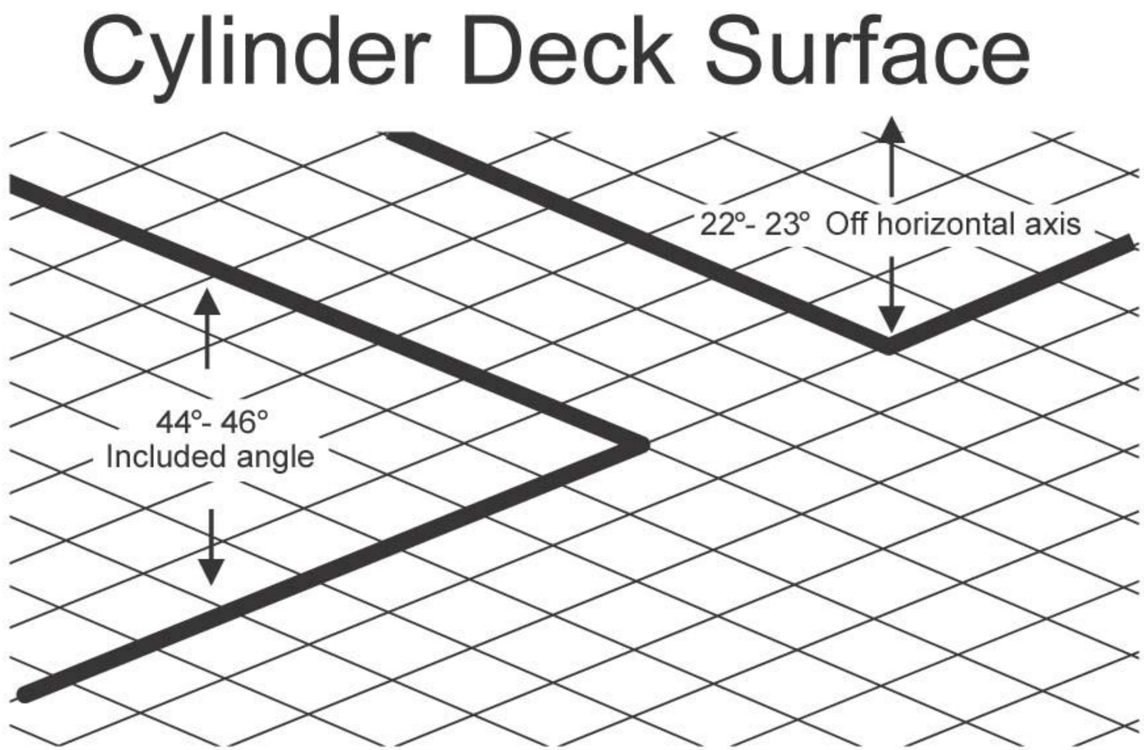
- 1. Drive easy
- 2. Drive hard
- 3. Drive slow than fast
- 4. Break in rings with no coolant
- 5. Pour Bon Ami down the carburetor

Cross Hatch Angle – Achieving Proper Cross Hatch Angle

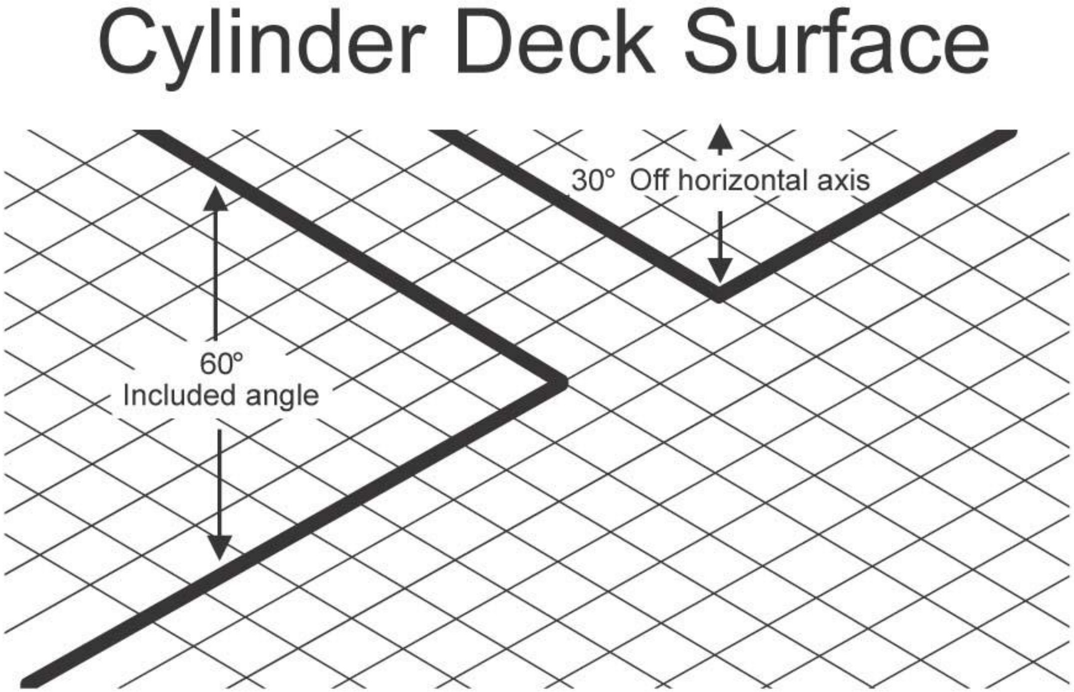
- Cross hatch angles help to determine ring rotation speed.

- Improper cross hatch angle can and will cause excessive blow-by, and oil control issues (lack of oil control).

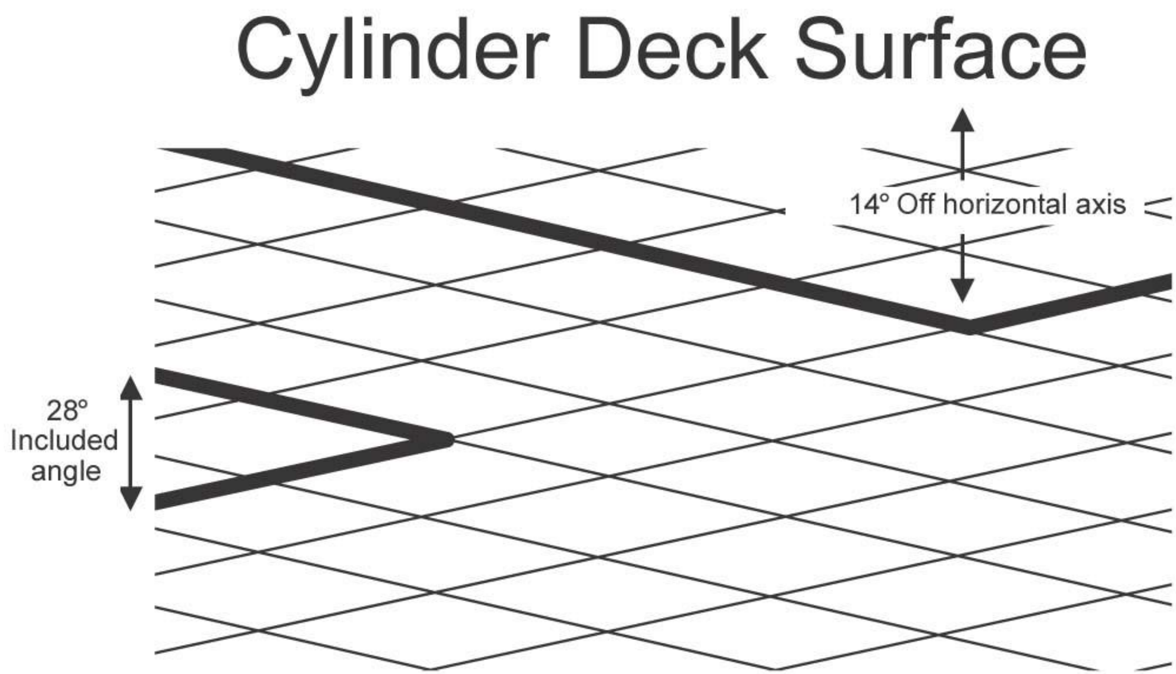
Proper Cross Hatch Pattern



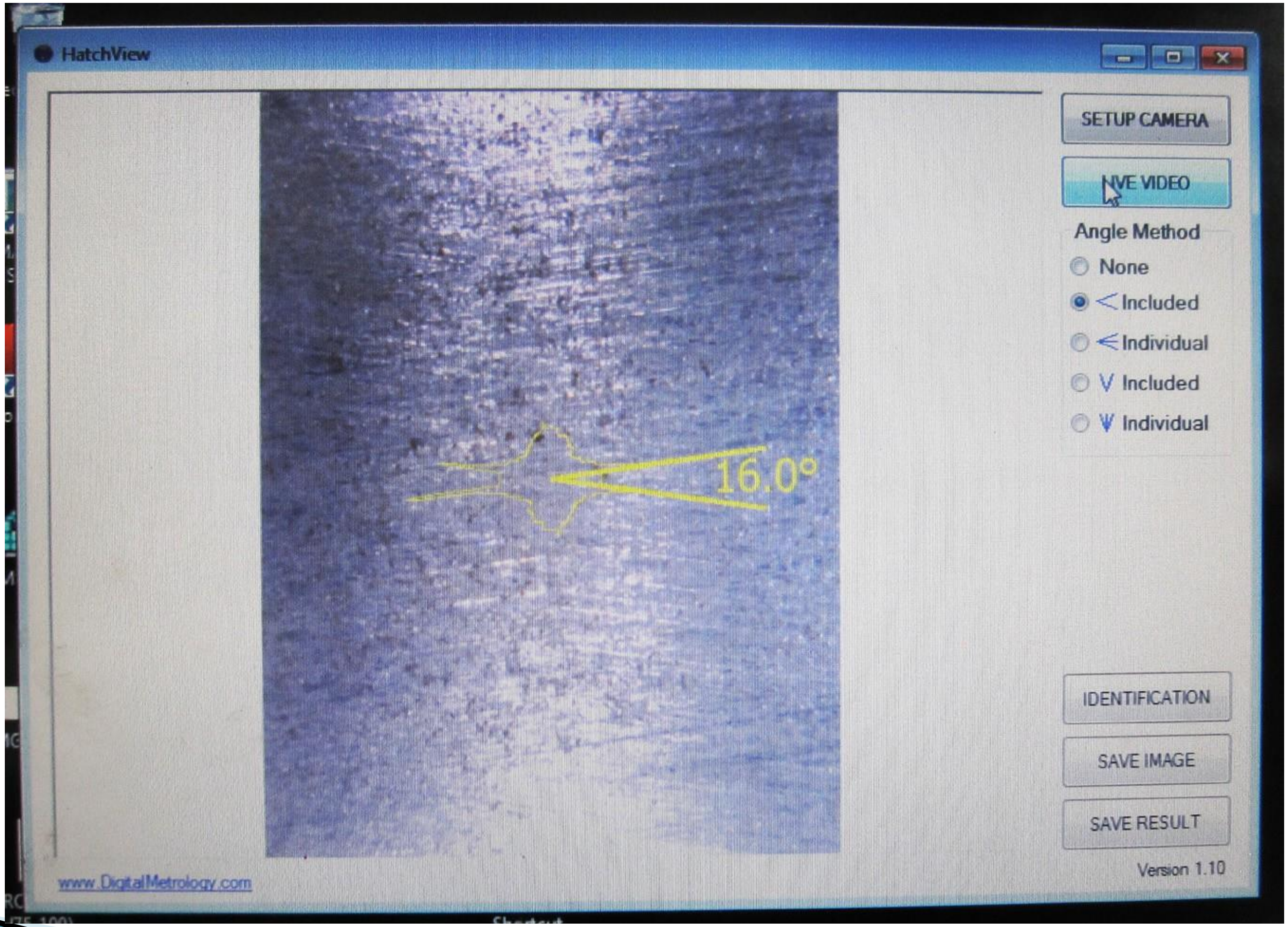
Too vertical (too steep) of a cross hatch angle can create excessive blow-by and high ring rotation speeds thus causing rings to align on the piston.



Too flat or too shallow of a cross hatch angle will create oil control problems as oil is being pushed horizontally not vertically down the cylinder. It can also create excessive blow-by as extremely flat angles cause the rings to ‘chatter’ as they travel in the cylinder.



Rottler Camera for Measuring Crosshatch Angles



What's Changed & What Are We Trying to Achieve

Purpose of a Piston Ring

- Seal Combustion Gases from the Oil Pan
- Seal Oil from Combustion Chamber
- Transfer Heat from the Piston into the Cylinder Wall

Ring Tension

COMPRESSION RINGS

Axial x Radial		Tension
5/64" x .190"	-	7.3 – 7.5 lbf.
1/16" x .190"	-	5.5 – 5.7 lbf
1.5mm x .160"	-	3.0 – 3.2 lbf.
1.2mm x .155"	-	2.3 – 2.5 lbf.
.043" x .155"	-	1.8 – 2.0 lbf.
.0325" x .135"	-	0.8 – 1.0 lbf.
.0274" x .110"	-	0.5 – 0.7 lbf.

OIL RINGS

Axial x Radial		Tension
3/16" x .187"	-	20 – 25 lbf.
3.0mm x .145"	-	9 – 11 lbf.
2.0mm x .125"	-	7 – 8 lbf.

Ring Tension

- When you look at the ring tension specifications from Total Seal you can see how important it is to have the correct surface finish free from torn metal and a round, straight cylinder for the ring to properly seal.

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What's Changed?

- Ring tensions
- Cylinder blocks/ liners much harder
- Oils
- Ways of Honing

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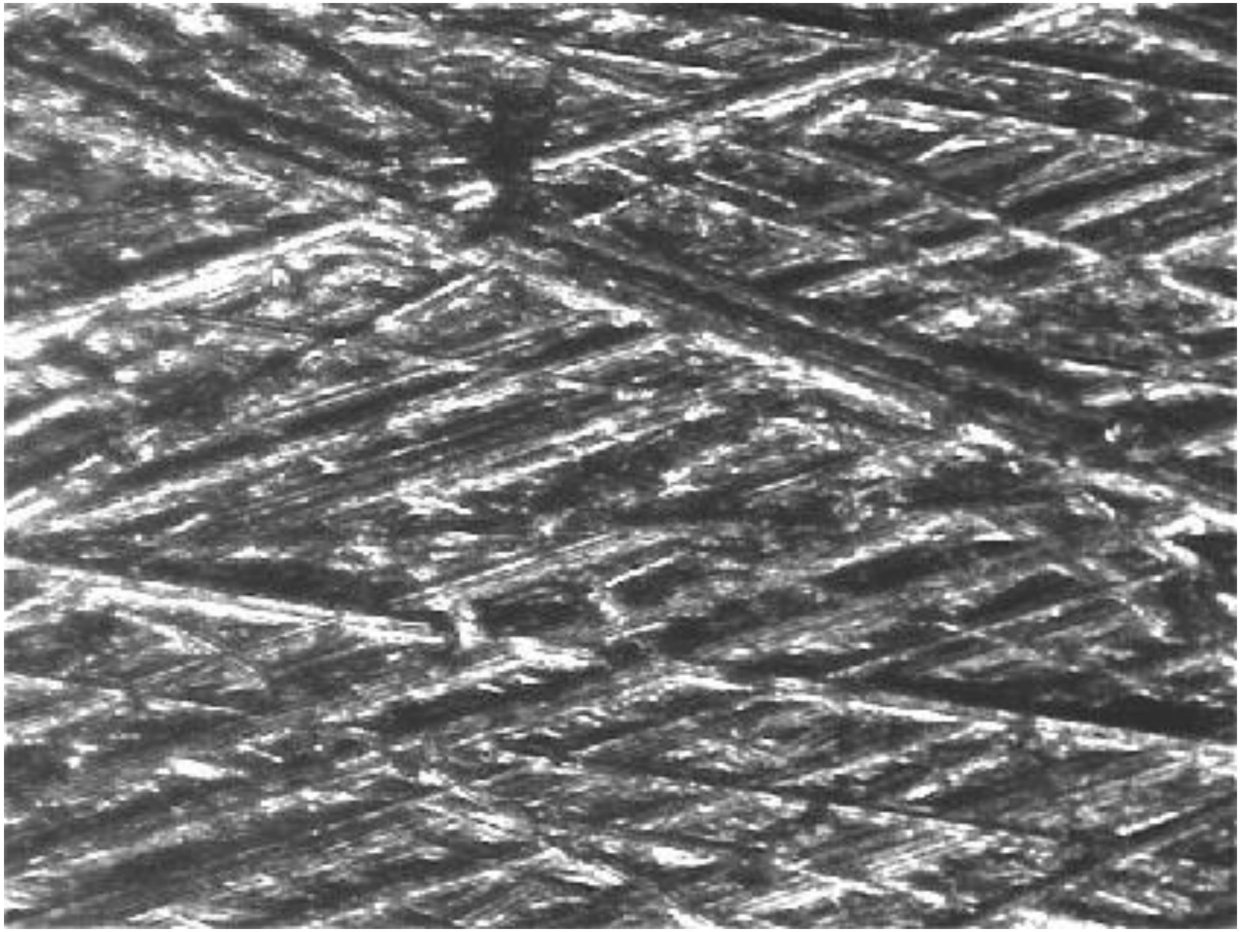
Ways of Honing Have Changed With the Use of CBN

Robert H. Wentorf, Jr.

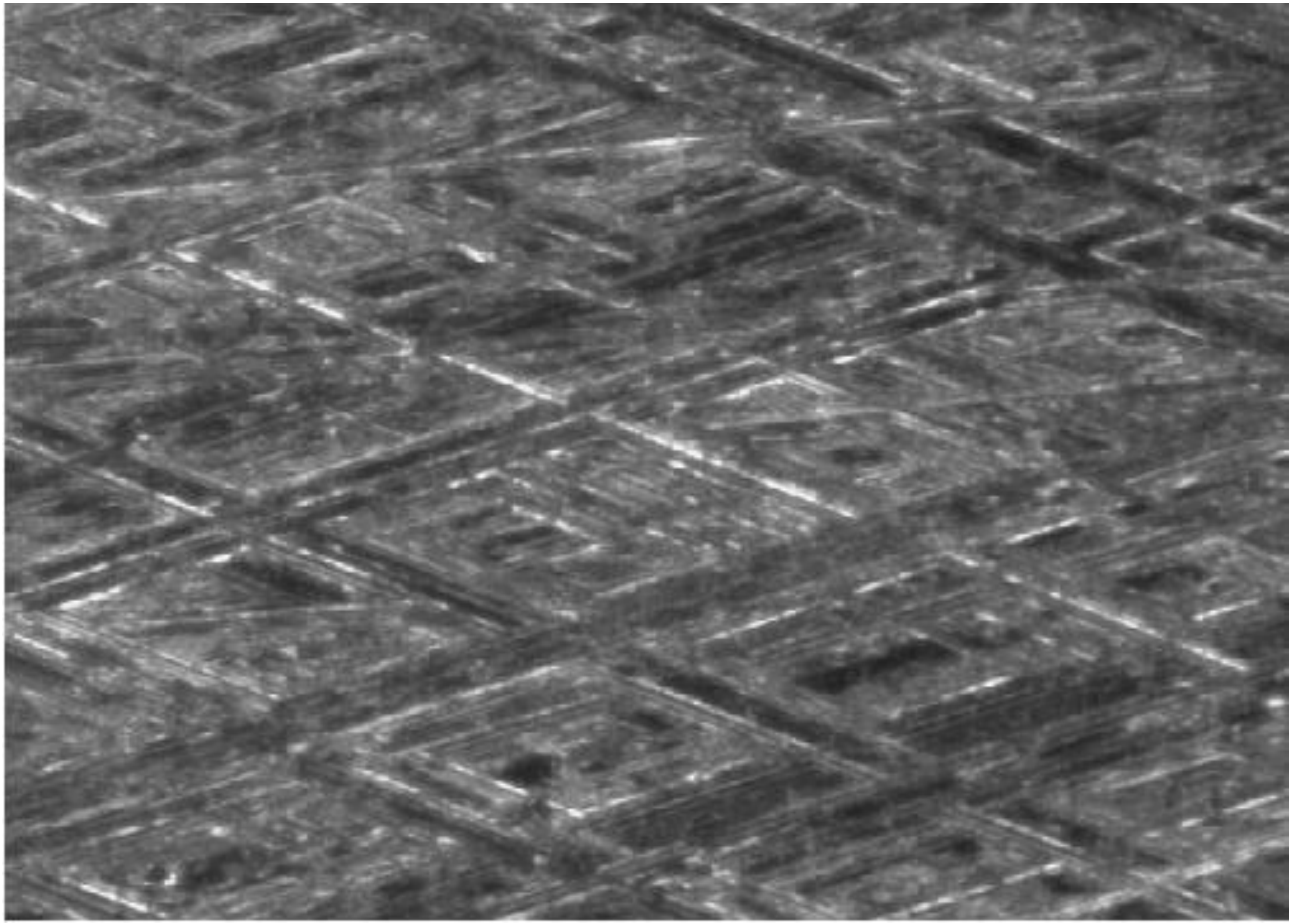
- (From Wikipedia, the free encyclopedia)
- Born May 28, 1926 in West Bend, Wisconsin
- Died April 3, 1997 in Easton, New York
- **Institutions:**
- General Electric
- Rensselaer Polytechnic Institute

Pictures of Honed Cast Iron Cylinders

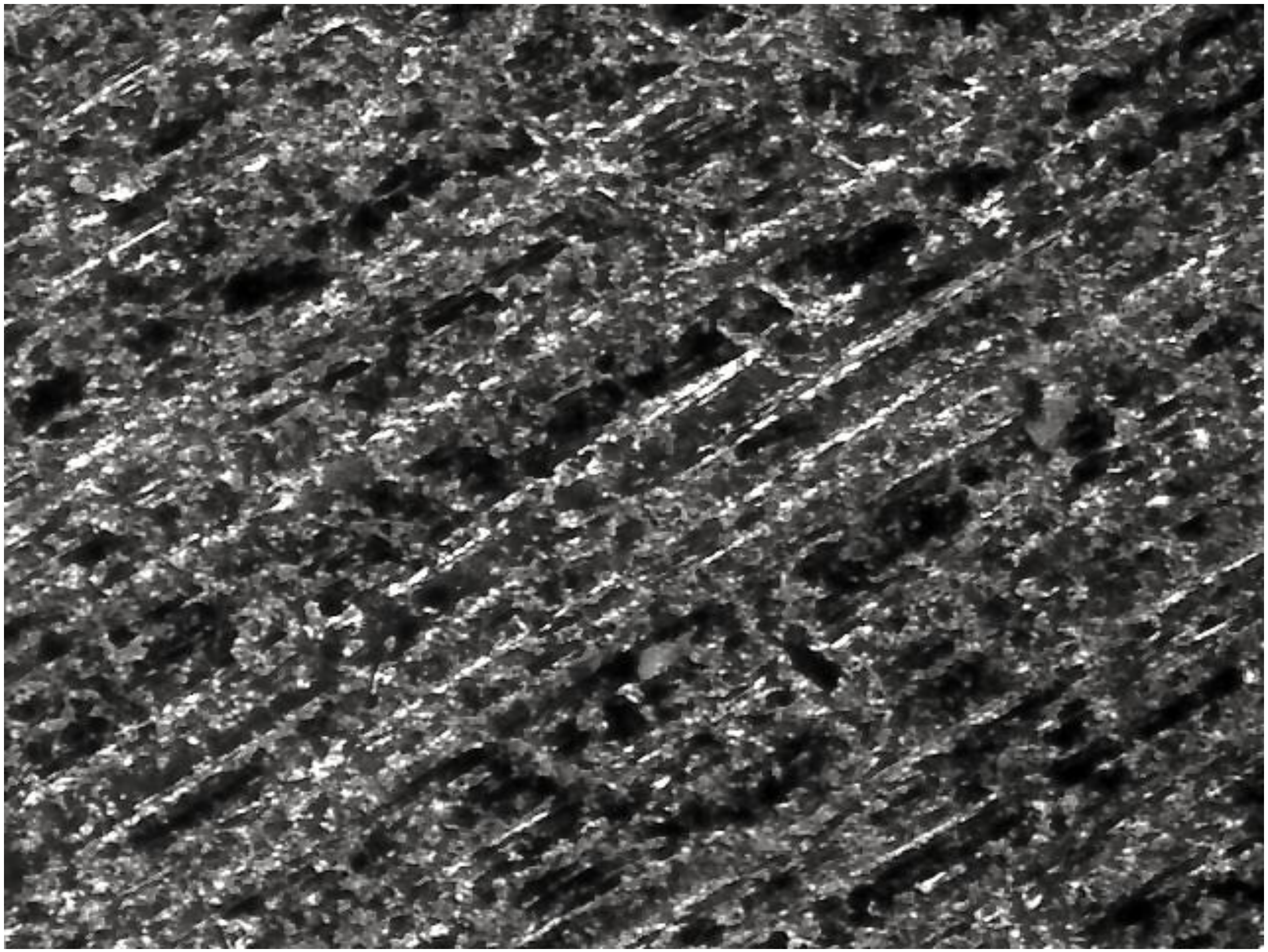
Vitrified Stone



CBN Stone



Diamond Stone



CBN, Vitrified, & Diamond Stones for Honing

Vitrified Stones

- Vitrified stones do not tear the cast iron but do not keep their shape to keep the cylinder straight & round.

Diamond Stones

- It is well known that diamonds need a high pressure to cut during honing. The high pressure tears the metal & leaves a lot of "junk" on the surface finish. You can see this in the pictures from diamond honing. This in turn makes an internal combustion engine cylinder distort. To counter act this distortion the pressure is reduced at the end of the honing cycle. This helps on the roundness & straightness but does nothing for the torn metal.

CBN Stones

It is also known that CBN takes much less pressure to cut during honing than diamond. The lower pressure does not leave the torn metal like diamond. This is shown in the pictures from CBN honing. When you use less pressure to hone you will get a rounder & straighter cylinder because there is less cylinder distortion.

Cylinder Honing

- There has been some dyno testing after using CBN to Plateau hone a cylinder that show a horse power increase .
- This may be due to the better sealing during the intake stroke & the power stroke.

CBN Stones

- **Rottler** has developed a Special CBN Stone, Software Program & Water Base Coolant combination for Cutting Edge Plateau Honing.

- This gets a cleaner cutting surface finish & less torn metal for today's piston rings.

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Plateau Honing with Rottler H80 Hones

- Rottler has a special program for Plateau honing that other do not have.
- RPM 80, 20% Load, & 5 Strokes
  - Stones are fed out 3 times before the cycle starts.
- Competitors use time or stock removal amounts (thousands per minute). They do not hold a constant pressure. This makes it hard to hold Rpk & Rvk readings.

Truing in CBN Stones

- The CBN stones must be trued in at 80 RPM, 20% load with (lapping grit optional).
- Must get line contact on CBN stone.

Thank You for your attendance!

Questions?

Melissa@rottlermfg.com

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