

Dressing Vitrified Superabrasive Wheels

Out of the ^(black) box ideas,

to get the most from your dressing and grinding process



Presentation Outline

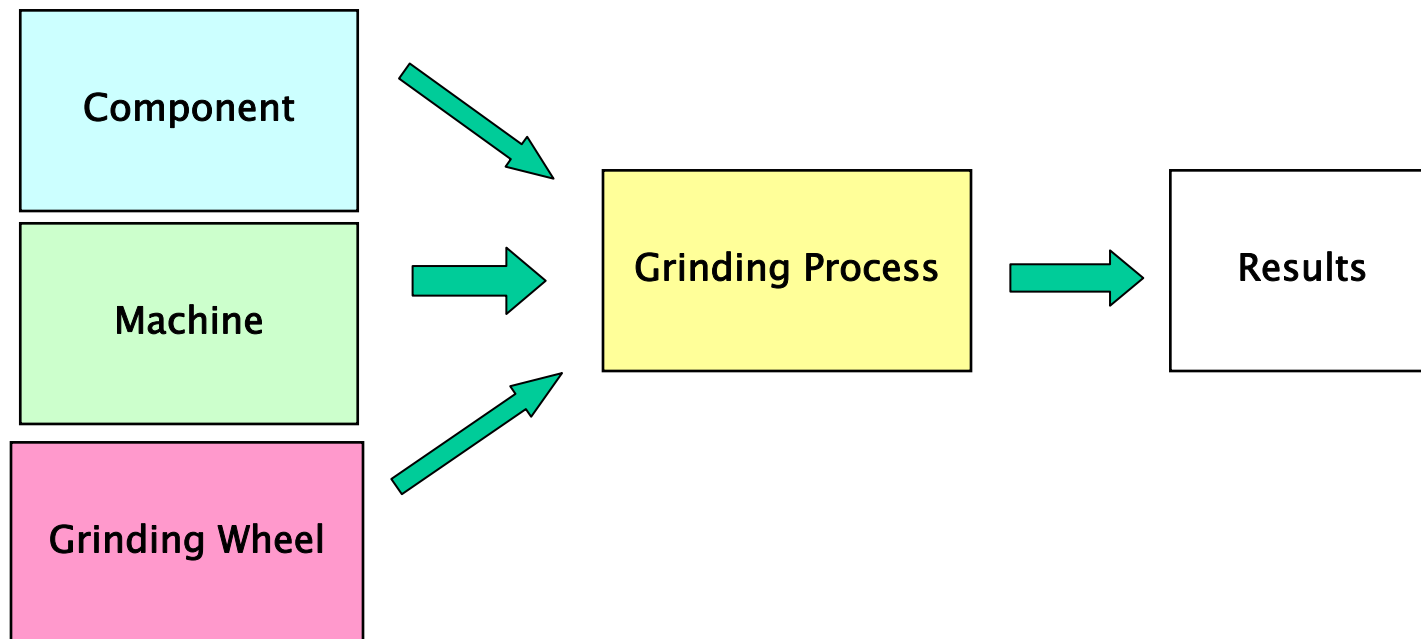
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- Introduction
- Wheel Dressing Defined
- Types of Dressing Tools
- Dressing Tool Selection for Vit Superabrasives
- Rotary Diamond Dressing Methods
- Rules of Thumb
- Case Study



Introduction

- Goals of this Presentation:
 - to provide a basic understanding of dressing principles to those who are new to wheel dressing
 - to provide information and tools to those who are already familiar with dressing concepts, to help them optimize their current processes.
- Grinding System:



Introduction

- Variables:
 - Wheel speed
 - Part speed
 - Infeed amount
 - Feed rate
 - Coolant application
 - *Wheel Conditioning (“Dressing”)*

Grinding Process



- Wheel conditioning, commonly referred to as “Dressing”, is a critical component used not only to sharpen, true, or profile the grinding wheel, but also to manipulate the way it behaves.



Introduction

- Dressing is sometimes referred to as a “black art”, and is one of the most frequently asked about topics by users of superabrasives.
- Dressing is actually a powerful tool for solving grinding problems, and has a direct impact on grinding results.
- The challenge: There is no magic formula or one-size-fits-all solution to achieving an optimal dressing process.
- Dressing is influenced by a large number of variables, and establishing a successful dressing process requires a fundamental understanding of those variables and how they interact and affect the outcome.



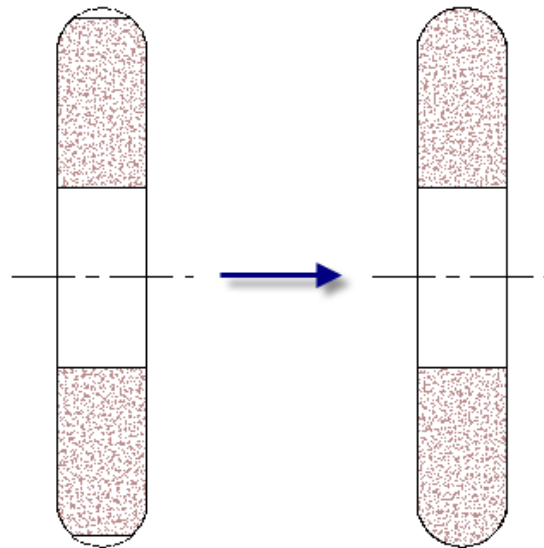
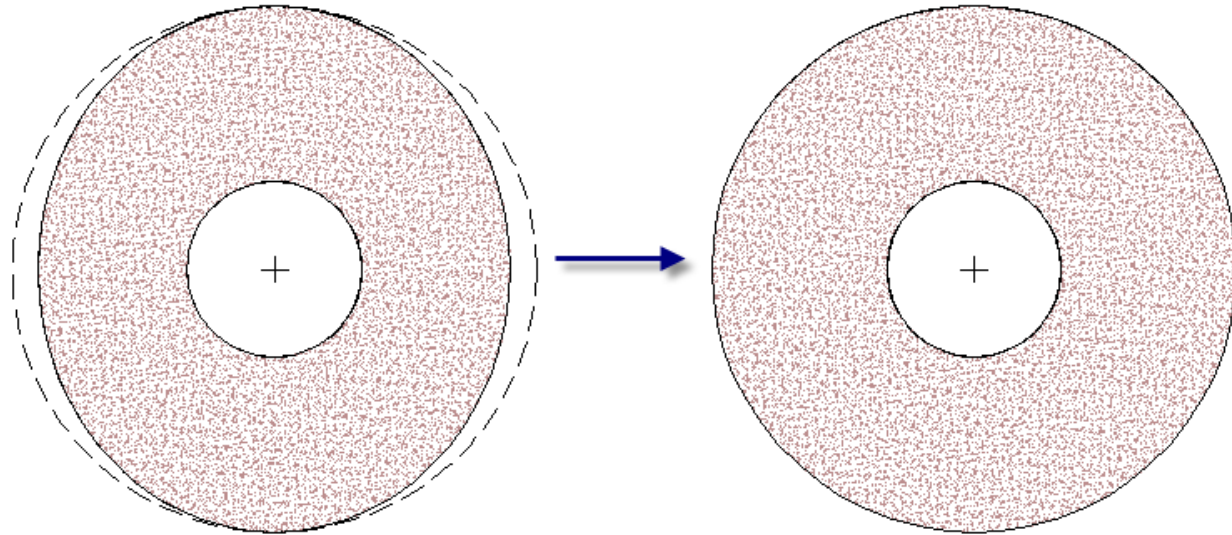
Wheel Dressing Defined

- The process of Dressing a grinding wheel can be broken down into two distinct parts; “truing” and “sharpening”
- Truing: the process of making an out of round wheel round again, or the process of re-profiling a form into the wheel.
- Sharpening: the process of removing bonding material to expose the abrasive grains.



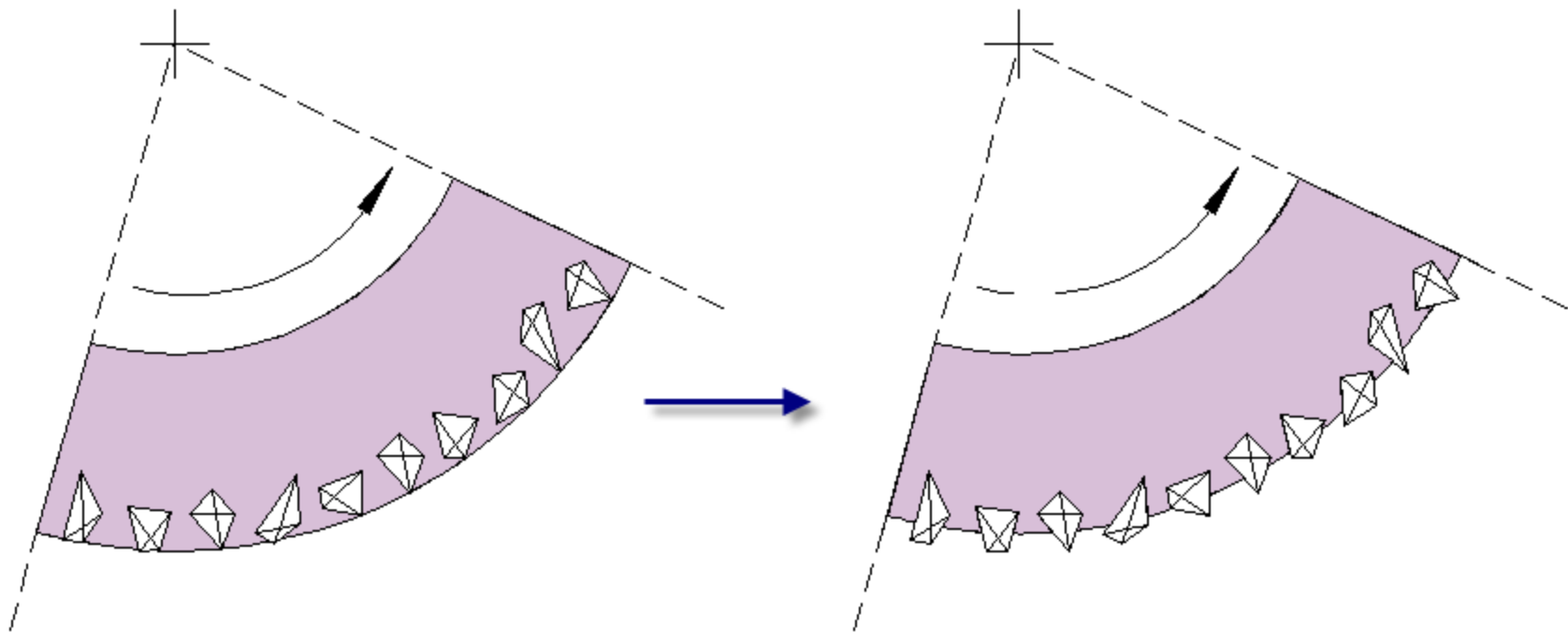
Wheel Dressing Defined

- **Truing:**



Wheel Dressing Defined

- Sharpening



Wheel Dressing Defined

- The process of dressing (truing and sharpening) is required periodically to maintain part geometry, quality, and process control.
- Some wheel types require a two step dressing process; one for truing, the second for sharpening. Other wheel types, such as those with vitrified bond systems have the unique ability to be trued and sharpened simultaneously.
- The cutting behavior of the wheel and the resulting surface finish, geometry, and quality of the parts are all influenced by the dressing process.
- Careful attention to the type of dressing tool, how it is used, and under what circumstances is critical to success.



Types of Dressing Tools

Sticks / Blocks

- Typically a sintered conventional abrasive product (SiC or Al₂O₃) with a soft bonding matrix.
- Designed to erode the wheel by attacking the bonding material.
- Widely used for sharpening in 2-step dressing processes.



Types of Dressing Tools

Conventional Abrasive Rotary Wheels

- Typically a sintered conventional abrasive in a vitrified bonding matrix.
- Used on driven or brake-controlled dressing spindles.
- Used for both truing and sharpening.



Types of Dressing Tools

Single / Multi-Point Stationary Diamond Tools

- Single point: High-quality diamond brazed to a steel shank
- Multi-point: either sintered (impregnated) or hand-set diamonds in an engineered pattern, mounted to a steel shank
- Used primarily for dressing conventional grinding wheels. Good for producing shapes and forms.
- Low wear ideal for CNC operations



Types of Dressing Tools

Rotary Diamond Tools

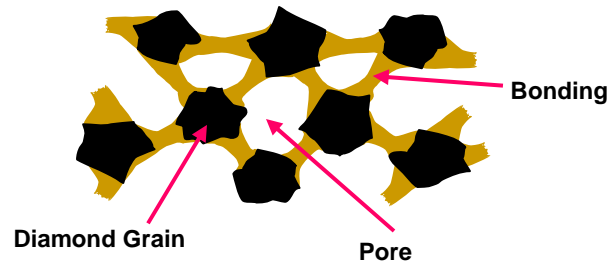
- Configurations: Cups, Disks, and Form Rollers
- Construction is typically one of the following:
 - a) Sintered (Impregnated) in vitrified, hybrid, or metal bondings
 - b) Plated Form Rollers
 - c) Mono-Layer
 - d) Hand-Set / Engineered Geometry (Diamond, PCD, or CVD)
- Rotary Tools are preferred for dressing superabrasive wheels, in particular vitrified-bonded CBN and Diamond wheels

<see more details of rotary diamond tools on the next page>

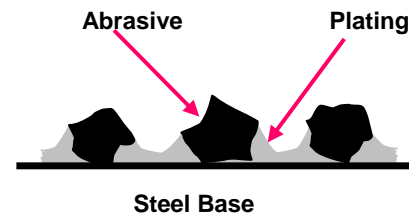
Types of Dressing Tools

Rotary Diamond Tools Continued...

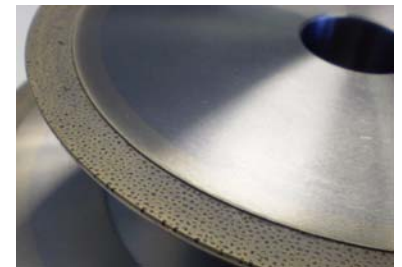
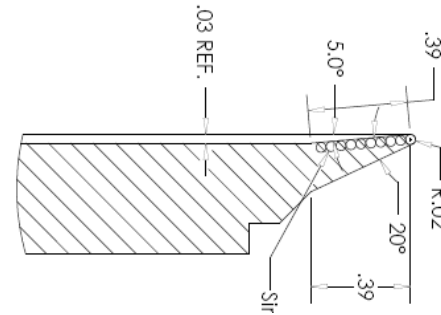
- Sintered:



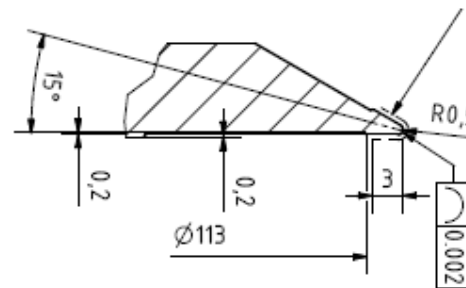
- Plated Form Roller:



- Mono-Layer:









- Hand-Set:



Dressing Tool Selection

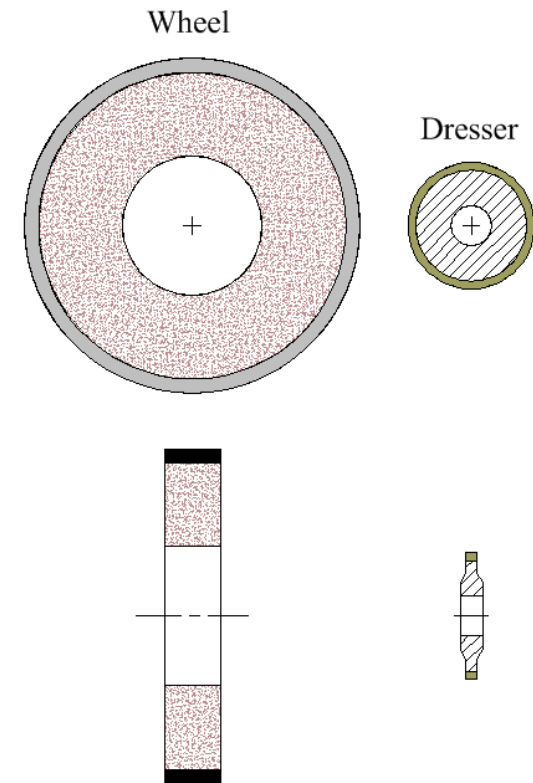
by Vitrified Superabrasive Wheel Type

Wheel Type	For dressing CBN	For dressing Diamond
Bore Wheels (<Ø100mm)  Straight  Formed	Rotary Diamond with Metal, Vit, or Hybrid bond	Rotary Diamond with Metal bond
	Rotary Diamond with Metal, Plated, or Hand-set matrix Alternative: Plated form roll	Rotary Diamond with Plated or Hand-set matrix
External Wheels (>Ø100mm)  Straight  Formed	Rotary Diamond with Metal or Hybrid bond	Rotary Dia. with Metal or Mono-layer; Alternative: conventional (SiC) wheel
	Rotary Diamond with Hand-set or Mono-layer matrix Alternative: Plated form roll	Rotary Diamond with Metal-bond (inverted) or Mono-layer matrix
Cup Wheels 	Rotary Diamond with Metal, Vit, or Hybrid bond	Conventional Rotary Wheel Alternative: Metal bonded Dia. followed by Alox stick
Fine Grinding Wheels 	Stationary Conventional blocks or rings (Alox)	Stationary Conventional blocks or rings (Sic and/or Alox)

Rotary Diamond Dressing Methods

Variables that affect the Dressing Process:

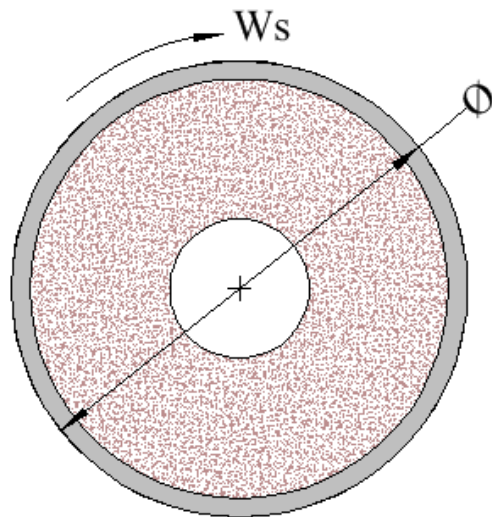
- Wheel and Dresser Surface Speeds
- Direction at point of contact
- Speed Ratio
- Infeed amount
- Traverse Speed
- Overlap Ratio



Rotary Diamond Dressing Methods

Surface Speed

- The surface speed is the linear speed at the periphery of the wheel or dresser.
- In bore grinding applications, the wheel speed for dress is typically the same speed as during grinding. In external grinding with larger wheels, the wheel surface speed is typically reduced to lower the dressing forces and wear on the dresser.



$$W_s = \frac{\pi \times \text{Ø} \times (\text{rpm})}{1000 \times 60}$$

where:

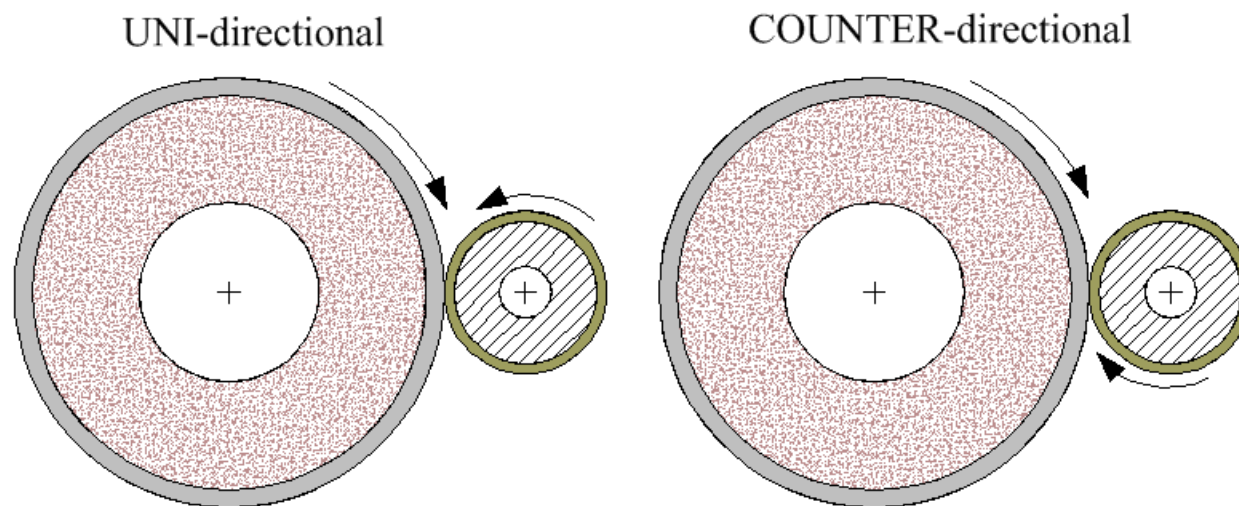
- W_s is in m/s
- Ø is in mm



Rotary Diamond Dressing Methods

Direction of Rotation at the Contact Point

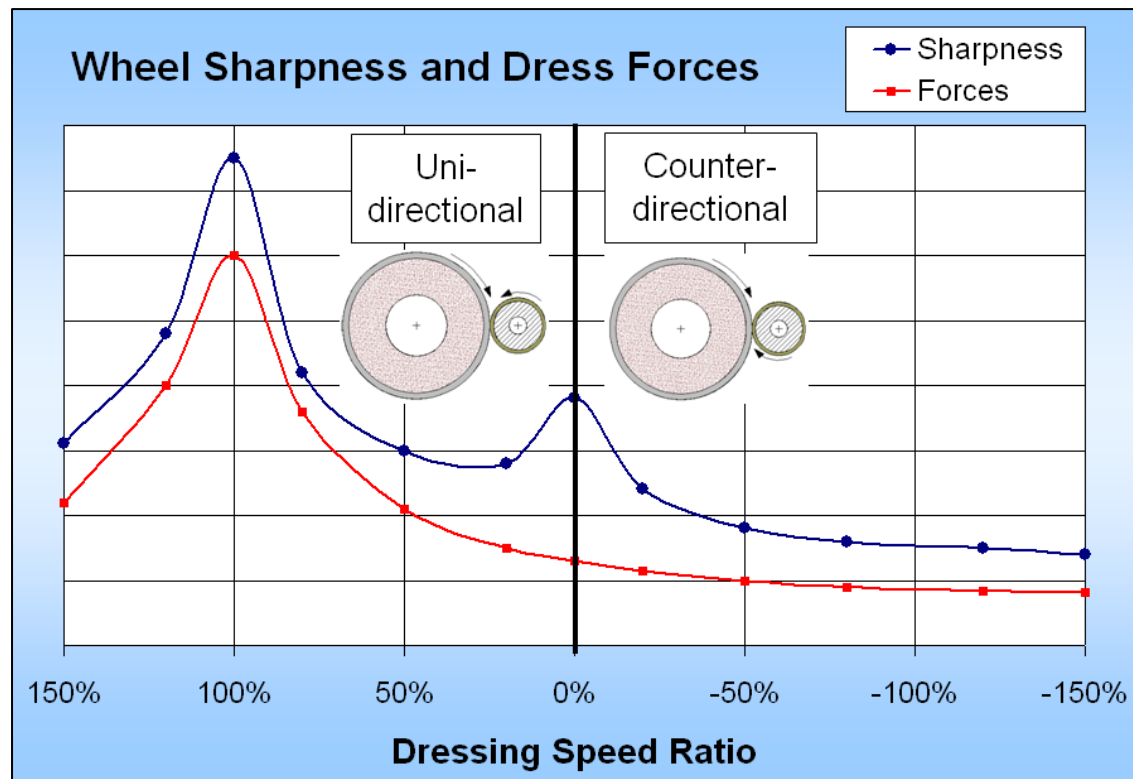
- Uni-directional: creates a crushing action between the dresser and wheel. Result is a rougher, sharper, more aggressive wheel surface. Dressing forces are higher, dresser wear is higher, and the resulting surface finishes on the part are rougher.
- Counter-directional: creates a shearing action between the dresser and wheel. Result is a smoother, duller, less aggressive wheel surface. Dressing forces are lower, dresser wear is lower, and the resulting surface finishes on the part are smoother.



Rotary Diamond Dressing Methods

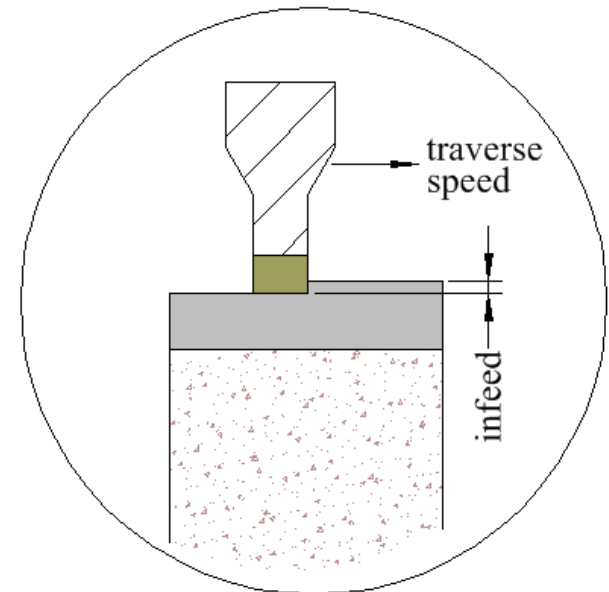
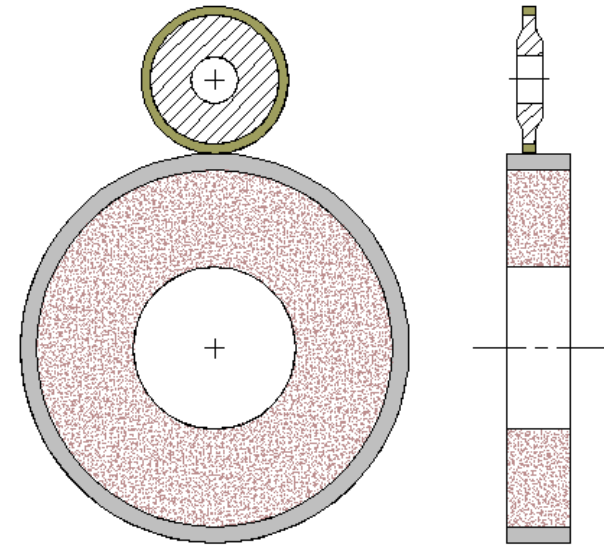
Speed Ratio

- The ratio of dresser surface speed divided by wheel surface speed. The speed ratio has a significant impact on the effective sharpness of the wheel and the forces experienced during the dressing operation. The optimal ratio seeks to strike a balance between these two variables.



Rotary Diamond Dressing Methods

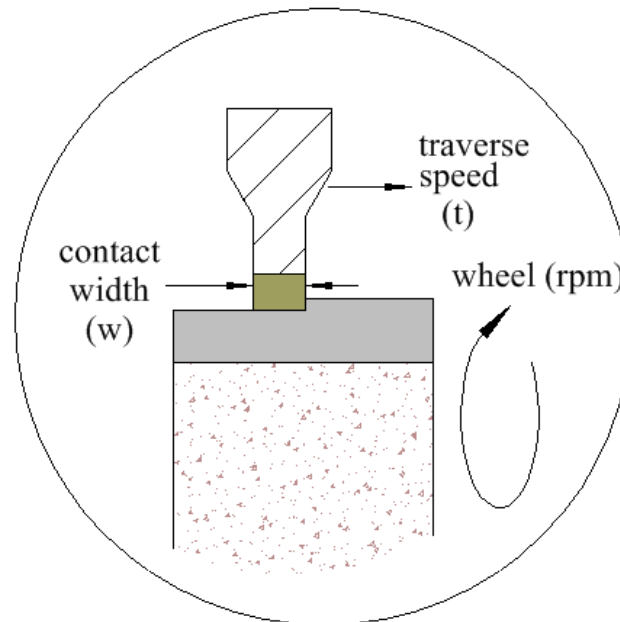
- **Infeed Amount:** the depth of cut taken per pass by the dresser on the grinding wheel. The goal is to fracture the dull abrasive crystals, exposing new sharp edges. Depths/pass are therefore well below the abrasive grain size. To correct geometry loss of the wheel, multiple passes should be taken instead of one deep pass.
- **Traverse Speed:** The linear speed that the dresser travels across the wheel surface. Faster speeds generate a sharper wheel surface, faster cutting speeds, and rougher part finishes. Slower speeds generate a smoother surface, slower cutting speeds, and smoother part finishes.



Rotary Diamond Dressing Methods

Overlap Ratio

- Defined as the number of wheel revolutions for the dresser to traverse a distance equal to its contact width.
- Generally speaking, the smaller the overlap ratio, the more aggressive the dress, whereas the larger the overlap ratio, the duller the dress.
- Overlap ratio is a way for engineers to combine several different variables into one number to help qualify the effect of their dressing cycle.



$$OR = \frac{w}{(t \div rpm)}$$

where:

- (w) is in mm
- (t) is in mm/min
- (rpm) – rev/min wheel

Rules of Thumb

general guidelines to help you get started...

Rough Grinding
Finish Grinding

Vitrified CBN Wheel Diameter	wheel speed (during dress)	direction	speed ratio	infeed/pass	overlap ratio
$\varnothing < 6$	same as grind speed (90k - 120k rpm)	Uni Counter	50% to 80% -50% to -80%	\varnothing (2 to 5) μm	200 to 750
$6 < \varnothing < 15$	same as grind speed (60k - 80k rpm)	Uni Counter	50% to 80% -50% to -80%	\varnothing (2 to 5) μm	15 to 100
$15 < \varnothing < 25$	same as grind speed (30k - 45k rpm)	Uni Counter	50% to 80% -50% to -80%	\varnothing 5 μm	9 to 50
$25 < \varnothing < 50$	slower dress speed (20-30m/s)	Uni Counter	50% to 80% -50% to -80%	\varnothing 5 μm	6 to 30
$\varnothing > 100$	slower dress speed (10-20m/s)	Uni Counter	50% to 80% -50% to -80%	\varnothing 5 μm	5 to 15

Vitrified Diamond Wheel Diameter	wheel speed (during dress)	direction	speed ratio	infeed/pass	overlap ratio
$\varnothing < 6$	same as grind speed (60K - 75k rpm)	Counter	-50% to -80%	\varnothing 2 μm	150 to 500
$6 < \varnothing < 15$	same as grind speed (30K - 45k rpm)	Counter	-50% to -80%	\varnothing 2 μm	15 to 75
$15 < \varnothing < 25$	slower dress speed 15m/s	Counter	-50% to -80%	\varnothing 2 μm	10 to 30
$25 < \varnothing < 50$	slower dress speed 15m/s	Uni Counter	50% to 70% -75% to -120%	\varnothing (2 to 3) μm	5 to 20
$\varnothing > 100$	slower dress speed 10-15m/s	Uni Counter	50% to 70% -75% to -200%	\varnothing (2 to 4) μm	5 to 15

Case Study

Dressing Process Improvements

Application

- Part: Hydraulic Sleeve bore grind
- Material: Steel (58HRc)
- Stock removal: $\text{Ø}0.4\text{mm}$
- Finish: $0.8\mu\text{m Ra}$
- Wheel speed: 50m/s
- Coolant: WSO
- Wheel: $\text{Ø}30\times 40$ Vit CBN
- DRESSING: Rotary Diamond $\text{Ø}120$ hand-set
- Parts/Dress cycle: 10
- Reason for dress: loss of size or taper tolerance on parts



Problems:

- Cycle time: too long (42sec, wanted $<37\text{sec}$)
- Taper/Size control: seeing (+) taper and unacceptable drop in bore size immediately after dressing cycle, which only corrected itself after grinding 2–3 parts.

Case Study

Dressing Process Improvements

- After reviewing the grind process, wheel, and dresser designs, we decided to have a closer look at the dressing process.
- It was determined the dress process was unnecessarily dulling the CBN wheel, causing it to build too much pressure during the grind cycle, resulting in quill deflection, which caused the taper and size control issues. Also, the dullness didn't allow the wheel to grind at its full potential stock removal.
- Below is the “before” and “after” dress process:

	BEFORE	AFTER
Wheel Speed for dress	30m/s (19,099 rpm)	30m/s (19,099 rpm)
Dresser Speed	50m/s (7,958 rpm)	24 (3,820rpm)
Direction	counterdirectional	unidirectional
Speed ratio	-167%	+80%
Infeed	Ø5µm	Ø5µm
Traverse	750mm/min	1250mm/min
Overlap	25.5	15.3

Case Study

Dressing Process Improvements

Results

- Able to increase grinding feed rates and get the cycle time down from 42sec to 36sec.
- Taper and size control dramatically improved. No more issues after dress.
- As a bonus, skip dress was able to be increased from 10 to 15 parts, allowing a much improved wheel life