3M Science. Applied to Life.™

3M Precision Grinding & Finishing

Solutions for Powertrain Industry.

A portfolio of high-performance abrasives and dressing systems, engineered to take you to the next level of precision and productivity

Engineered for precision and productivity

Ever since the first mass-produced cars rolled off the assembly line in the early 20th century, 3M abrasives have been helping manufacturers improve productivity and enhance the quality of products that move our modern world. Through the years we have continued to expand our abrasive technology offerings to meet the growing needs of customers who produce sophisticated components for automotive engines and transmissions, as well as oil and gas drilling equipment, cutting tools, aircraft, turbines and many others.

Today we are pleased to offer one of the world's most extensive portfolios of precision abrasives for grinding and finishing powertrain components.

In these pages, you will find a selection of some of our most advanced abrasive products used in these applications. Your 3M representative can help you select specific products best suited for your requirements.

From grinding-to-dimension to microfinishing, 3M has the tools you need to help you be more productive, while achieving stringent geometry tolerances and finish specifications, part after part.

A proud history of research

Founded in 1902 to mine minerals used in grinding wheels, 3M has grown to become one of the world's leading manufacturers of high-performance abrasive products, with a broad portfolio ranging from sandpaper for the do-it-yourself market to advanced abrasives used by the automotive, aerospace, electronics and medical device industries.

Building on its century-long legacy of expertise in coated abrasives, including the introduction of the first waterproof sandpaper, the development of synthetic ceramic abrasive grain and microreplicated abrasive shapes under the 3M™ Trizact™ brand, 3M began an aggressive expansion into bonded abrasives in the 1990s with a series of strategic acquisitions. These include companies such as GIDCO, UNIFAM, DPI and, in 2011, Winterthur Technology Group, one of the world's top manufacturers of industrial bonded abrasives.

Power and precision

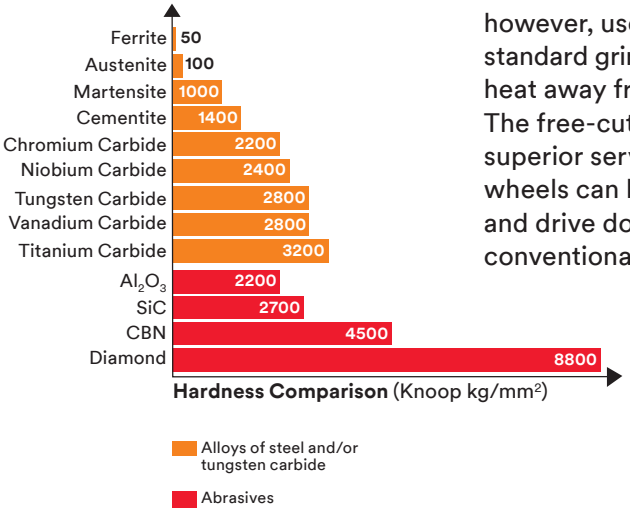
3M offers a complete line of high performance abrasive wheels in shapes, sizes and constructions designed to meet the needs of the most demanding applications. They are available in three general abrasive types within powertrain component applications:

Conventional

Conventional grinding wheels with aluminum oxide or silicon carbide abrasive minerals play an important role in metalworking applications. For grinding processes such as gears in the automotive industry and cylindrical grinding of gasoline and diesel injection components, conventional grinding wheels offer a precise and cost-effective means of production.

Cubic Boron Nitride (CBN)

CBN abrasives are second only to diamond in hardness. This makes CBN wheels highly durable, with accurate geometric control. Ideal for grinding hardened materials and superalloys, CBN abrasives can be used in a variety of bonding systems, including vitrified and electroplated bonds, to tailor wheel performance to specific applications. Available in grit sizes 50–600.



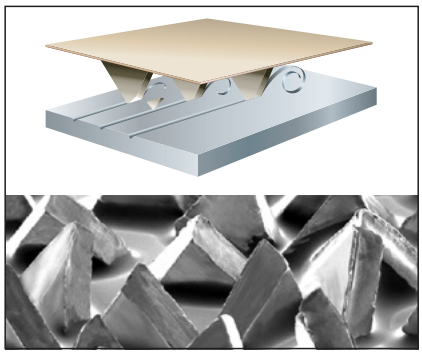
3M Precision-Shaped Grain

3M first introduced this break-through technology in 2009 with the launch of 3M™ Cubitron™ II Fiber Discs and Belts. Comprised of uniformly sized triangles of ceramic aluminum oxide, 3M precision -shaped grains are designed to fracture as they wear, continuously forming sharp points and edges that slice cleanly through the metal like a knife, instead of gouging or plowing. This prevents heat from building up in the workpiece – reducing heat-related stress cracks and discoloration. And, because the abrasive itself stays cooler and sharper, it lasts up to four times as long as conventional ceramic grain.

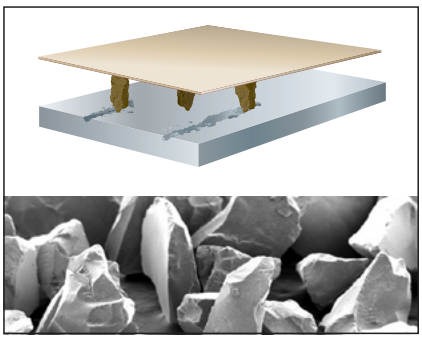
With conventional abrasives, standard grinding consumes up to 10 times more energy than other metal removal processes, such as turning or milling. The sharp cutting edges of Cubitron II grinding wheels, however, use less energy than standard grinding – while diverting heat away from the workpiece. The free-cutting properties and superior service life of Cubitron II wheels can help improve efficiency and drive down costs, compared to conventional ceramic wheels.

The science of 3M Precision-Shaped Grain

The secret behind the strength and performance of Cubitron II vitrified wheels lies in the revolutionary precision-shaped ceramic grain technology pioneered by 3M. As the triangular shaped grain wears, it continuously fractures to form sharp points and edges that slice through metal, wear evenly and provide super-long life and consistency.



3M Precision-Shaped Grains “slice” through metal – staying cooler, cutting faster and lasting longer.



Conventional ceramic abrasive grain tends to “plow” through the metal, causing heat to build up in the workpiece and the abrasive.

The next generation of vitrified bonds

Most vitrified wheel bonds consist mainly of naturally occurring raw materials such as kaolin (porcelain clay), feldspar and glass frits, all of which are subject to variations in quality. Such variability is ill-suited to modern automated grinding processes operating with pre-determined machining parameters. To ensure more uniform batch quality, 3M uses fully synthetic recrystallized glasses in the bonding systems of their vitrified wheels. Due to their high inherent strength, these glasses can be used in smaller quantities than standard bonding materials, allowing increased porosity without compromising wheel strength.
3M™ Vitrified Grinding Wheels feature advanced bonding systems for various applications.

Strength
Partially crystallized glass bond wheels have high inherent strength and can be used in smaller quantities than standard bonding materials. This allows for a reduction of 10% in overall bond material and a simultaneous equal increase in porosity, without any loss of wheel strength.

Consistency
These grinding wheels feature special bond grain surface structures based on nanotechnology. The grinding wheel remains free-cutting throughout the entire process and life of the wheel while the machine uses less spindle drive power, all resulting in more consistent surface structures.

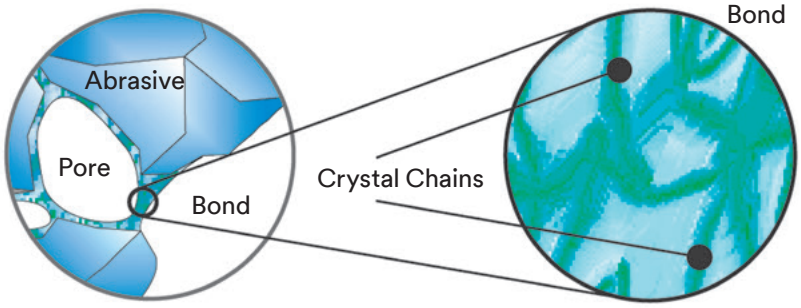
Economical
3M can also offer bond systems to deliver higher material removal rates along with lower risks of burning, better profile holding and reduced reject rates. In short, this bond offers the end-user significantly lower grinding costs and more stable processes – and it is also very easy on diamond dressing tools.

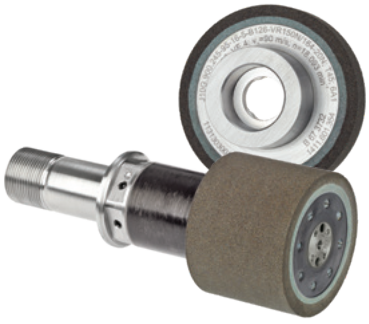
The bond of a grinding wheel is what holds the abrasive material in place, but by itself does not grind. Generally, the more bond in a wheel construction, the higher the danger of burning and micro-cracking within the part; the less bonding material, the cooler the wheel will grind. To achieve optimum performance, wheels should be constructed with as little bonding material as necessary to preserve mineral retention and maintain wheel integrity and safety. 3M abrasive materials for powertrain applications are applied to wheels using one of two bonding methods:

Vitrified wheels
Vitrified wheels feature a ceramic bond designed to be more free cutting than metal bond wheels. Vitrified bonds provide the better characteristics of both resin and metal bonded products. They are brittle, but thermally stable and suitable for in-process dressing. Their dressability makes them particularly well-suited for form grinding applications, especially on automatic equipment. When used with diamond abrasive, they are ideal for grinding carbide, ceramics, CVD, PCD and metal matrix composites. With CBN, ceramic or conventional abrasives, they are commonly used for grinding hardened steel, tool steels and superalloys, and are particularly suitable for powertrain components, bearings, aircraft engine and power turbine components.

Electroplated wheels
Electroplated wheels enable high material removal rates with less generation of heat, making them ideal for hard materials such as nickel and cobalt-based alloys, ceramics and tungsten carbide. Employing a single layer of diamond or CBN abrasive electroplated to a substrate, these wheels can be constructed with tight dimensional tolerances. They are typically not trued or dressed.

Grinding Wheel Structure

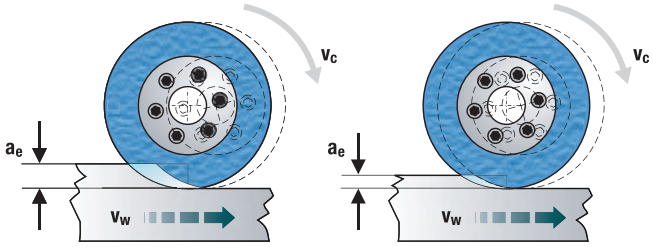




An introduction to grinding

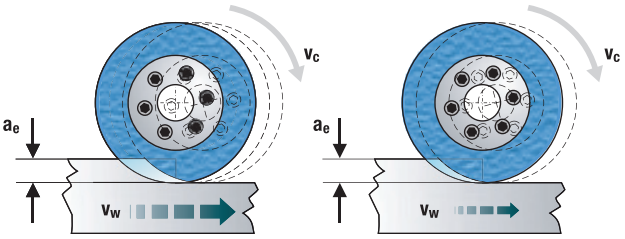
The following diagram describes some of the most common factors that can impact a particular grinding process:

Changing the infeed or depth of cut a_e



Increasing the infeed	Decreasing the infeed
Increased material removal rate	Reduced material removal rate
Bigger chips	Smaller chips
Higher load on individual grain	Lower load on individual grain
Increased friability of grain	Decreased friability of grain
> The grinding wheel acts harder	**> The grinding wheel acts softer**

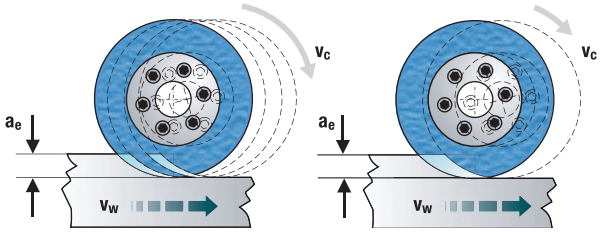
Changing the workpiece feed rate v_w



Increasing the feed rate	Decreasing the feed rate
Increased material removal rate	Reduced material removal rate
Bigger chips	Smaller chips
Higher load on individual grain	Lower load on individual grain
Increased friability of grain	Decreased friability of grain
> The grinding wheel acts harder	**> The grinding wheel acts softer**

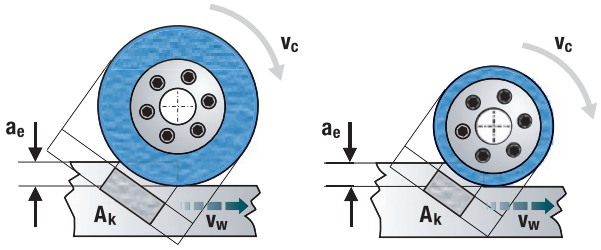
Depth of Cut (per pass): a_e
Workpiece speed: v_w
Cutting or surface speed: v_c
Grinding wheel diameter: d_s
Lubricity of grinding fluid

Changing the wheel cutting speed v_c



Increasing cutting speed	Decreasing cutting speed
More cutting edges engaged per unit of time	Fewer cutting edges engaged per unit of time
Smaller chips	Bigger chips
Lower load on individual grain	Higher load on individual grain
Decreased friability of grain	Increased friability of grain
> The grinding wheel acts harder	**> The grinding wheel acts softer**

Changing the wheel diameter d_s (at the same wheel cutting speed v_c)



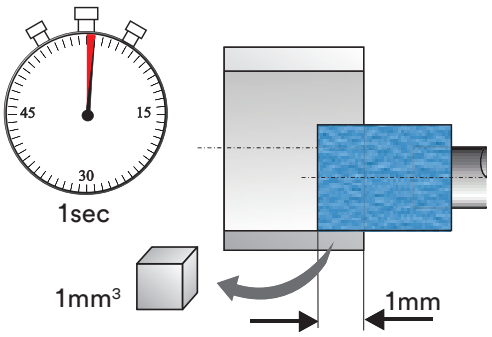
Increasing wheel diameter	Decreasing wheel diameter
Increased contact area A_k between wheel and workpiece	Decreased contact area A_k between wheel and workpiece
Grinding forces remain practically constant	Grinding forces remain practically constant
Lower load on individual grain	Higher load on individual grain
Decreased friability of grain	Increased friability of grain
> The grinding wheel acts harder	**> The grinding wheel acts softer**

The aggressiveness factor

The specific material removal rate Q_w' (also known as Q-prime) is often used to evaluate the performance of a grinding wheel. Q-prime indicates how many mm^3 one (1) mm wheel width removes per second ($mm^3/mm/sec$). To calculate Q-prime, two parameters are needed: depth of cut a_e and the feed rate v_{Fr}.
The simple formula for surface grinding is as follows:

$$Q_w' = \frac{d_w \cdot \pi \cdot v_{Fr}}{60} \left[\frac{mm^3}{mm \cdot s}\right]$$

d_w = workpiece diameter in mm
v_{Fr} = radial feed rate in $\frac{mm}{min}$



Recommended Q-prime values:	
0.3 $mm^3/mm/sec$	Finishing
1.0 $mm^3/mm/sec$	Good average
1.5 $mm^3/mm/sec$	Target value
5.0 $mm^3/mm/sec$	High performance grinding with ceramic abrasives or CBN

Gear grinding

Gear grinding requires high precision throughout the process, and it is important to use the right grinding wheel for the application. The selection of abrasive material and wheel configuration depends on the base alloy, tooth geometry and size of the production run, among other factors. 3M's recently expanded abrasives portfolio can help you meet the growing demand for tighter dimensional tolerances and shorter production schedules, even with difficult-to-grind materials.

Gear grinding operations

Continuous generation with threaded (or "worm") wheels produces a very accurate and consistent profile. Advantages include low cumulative pitch error, constant contact with gear profile, and short machining cycles.

Form or profile grinding
Form or profile grinding with single rib wheels is increasingly used over single flank generation. The gear tooth profile is dressed into the grinding wheel by means of a CNC contour controlled diamond dressing disc. The grinding wheel is then fed into the tooth gap, either vertically or with a rotary infeed. This process can be compared to creep-feed grinding.

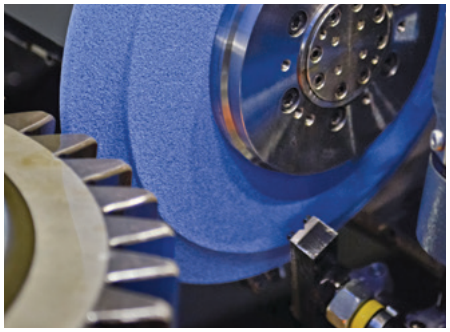
Plunge grinding
Plunge grinding is primarily used with spiral bevel gears with induced porosity, because of the larger contact surface areas required.

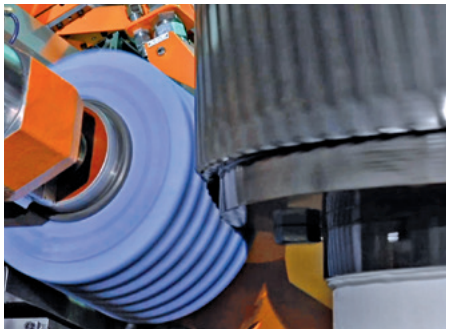
Generation with five axes
Generation with five axes with standard structure grinding wheels is used principally for spiral bevel pinions.

Continuous profile plunge grinding
Continuous profile plunge grinding with globoidal wheels combines the best aspects of form and plunge grinding. Very short grinding times and high accuracy; economic high-volume production; improved noise characteristics of gears.

Abrasive materials for gear grinding

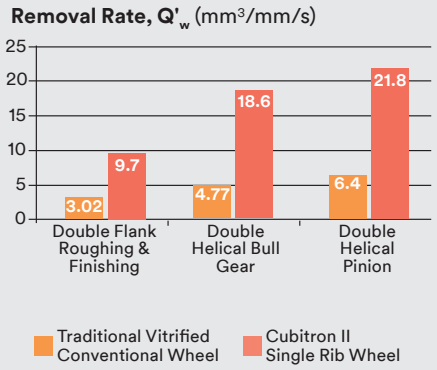
Gears are usually made of low to medium-hard alloys or quenched and tempered steel, and for economic reasons these materials are usually ground with conventional abrasives. CBN may be useful for grinding hardened steel, with large lot sizes, or for driveshafts featuring multiple gear wheels that prevent the use of threaded grinding wheels. Some gearbox manufacturers use electroplated CBN grinding wheels in order to reduce noise generation when paired with gears manufactured by other methods. CBN grinding can also generate compressive, residual stress on the gear flank surface, which increases the life of the component.

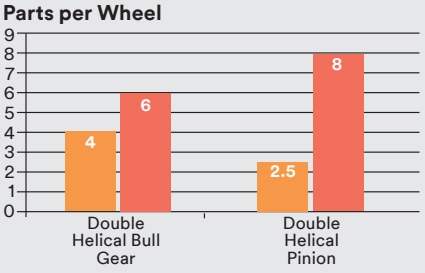




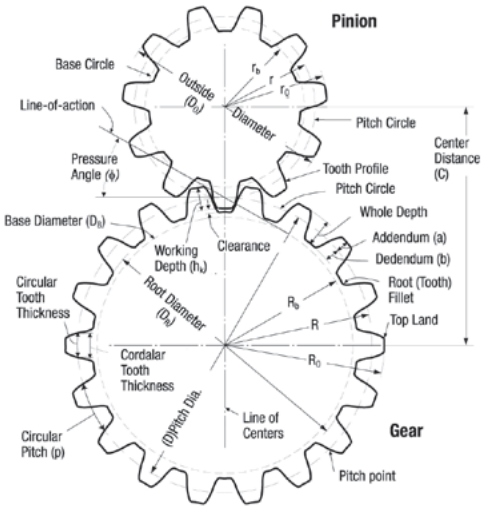
Recommended products
3M™ Abrasives for gear grinding are engineered to help you achieve consistent, high-quality finishes and tight geometry tolerances, part after part – while increasing the efficiency and productivity of your operations.

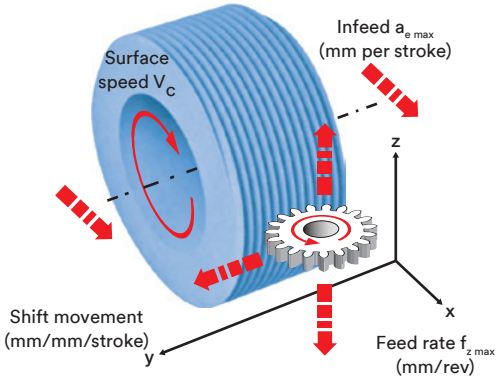
3M™ Cubitron™ II Vitrified Wheels
for gear grinding – threaded, single rib and spiral bevel configurations. For automotive applications; pinion shafts; planetary, spur, hollow and pinion gears.





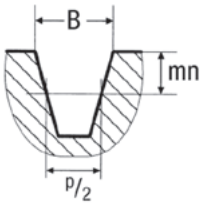
American gear terminology





Calculating wheel thickness for worm or threaded gear grinding

Single-Rib Wheels



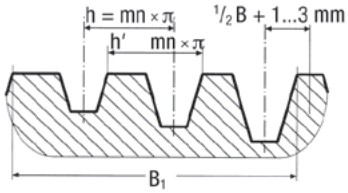
$$B = \frac{p}{2} + 2 \times mn \times \tan\alpha$$

when $\alpha = 20°$ $B_{20} \cong mn \times 2.3$

when $\alpha = 15°$ $B_{15} \cong mn \times 2.1$

B = Wheel Thickness
p = Pitch
mn = Module

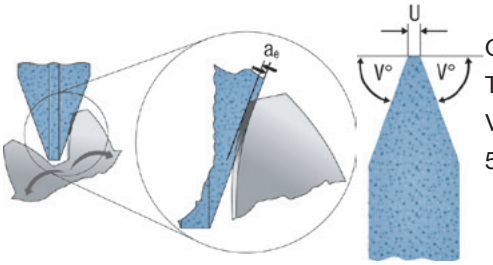
Multi-Rib Wheels



$$B_1 = z \times mn \times \pi$$

B = Wheel Thickness
z = Number of Teeth
mn = Module
h = Pitch

Wheel specifications for generating grinding of gear flanks



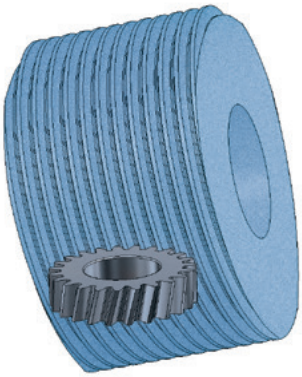
Ordering data example
Type 1Esp 300 × 32 × 127
V = 70°, U = 5
54A80 H15VPMF904W

Gear grinding with ceramic abrasives

Order data examples

Pre-profiled grinding worm:
Type 1sp 350 × 104 × 160
93A120 G12VP601-50 m/s
Module 4, PA 20°
Single start

Straight non-profiled wheel:
Type 1 350 × 104 × 160
93A120 G12VP601-50 m/s



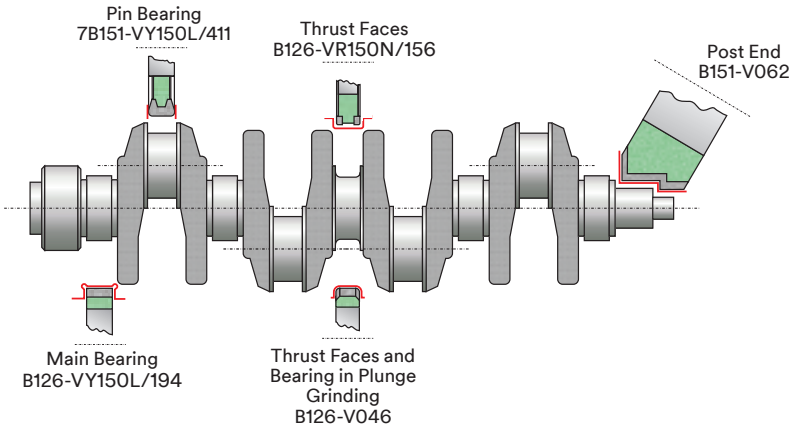
Camshaft and crankshaft grinding

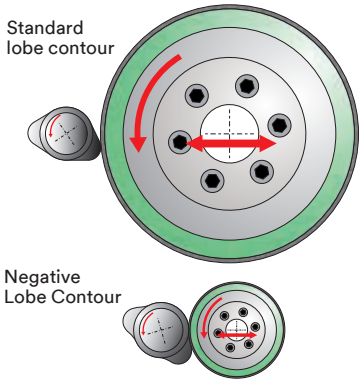
3M's comprehensive abrasives portfolio offers solutions from rough grinding to superfinishing of steel and cast steel alloys – ideal for camshaft and crankshaft applications.

Camshaft and crankshaft grinding operations

Main contour grinding is performed by CBN wheels with either continuous or segmented rims; both centerless and OD cylindrical grinding operations are used. Applications include bearings/journals, crankpin, flange and post end.

Cam lobes with concave/negative contours cause less friction and allow higher valve lift acceleration. This lobe design helps reduce fuel consumption and increase engine efficiency. These contours are ground with vitrified CBN wheels in the range of Ø 70 to 100 mm (Ø 3 to 4 inch).

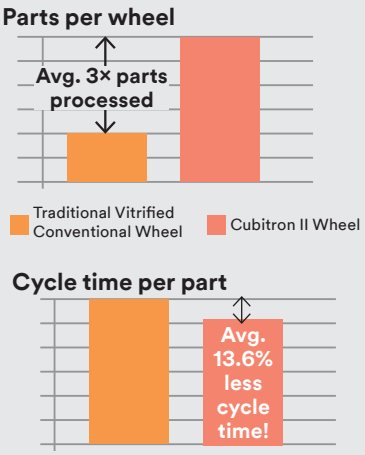




Recommended products

3M™ Cubitron™ II Vitrified Wheels
– for automotive and truck applications, including journals, crank and thrustwall.

Camshaft Grinding: 3M™ Cubitron™ II wheels vs. traditional vitrified conventional wheels



3M™ Electroplated CBN Wheels
Non-crushed for roughing or crushed for fine surface finishes. High-performance and high-precision. Ideal for grinding pins, bearings and face slots.

3M™ Vitrified CBN Wheels
Available in continuous rim (up to 30 in. diameter) or segmented rim sections. Variable density and porosity, can be adapted for your application specifications. Ideal for grinding camshaft lobes and bearings.

Abrasive Materials for Camshaft & Crankshaft Grinding
Recommended CBN grit concentrations differ according to the application:

Crankshaft grinding: 125 (rigid machines up to 150)

Camshaft grinding: 150–200

Cylindrical grinding

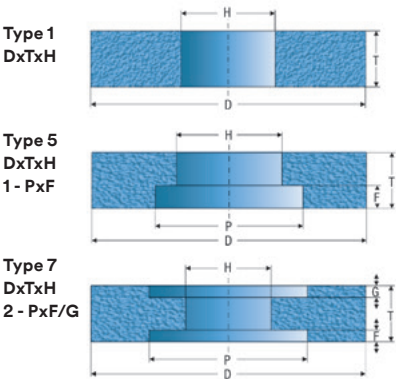
As cylindrical grinding technology continues to evolve, 3M has invested in the development of a wide variety of high-quality grinding wheels to remove material faster, at precise tolerances, without damaging the substrate. We have wheels available for the most popular worm grinding, form grinding, plunge grinding and transverse grinding machines.

Cylindrical grinding operations

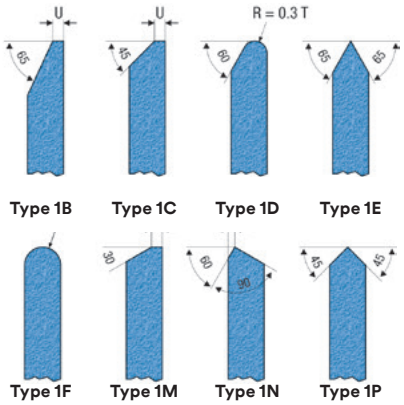
Outside diameter (OD) grinding is one of the most frequently used grinding techniques. The workpiece is clamped firmly between two centers and rotated. The grinding wheel is fed in one of two principle directions:

- Plunge grinding is often divided into several process steps, performed in sequence with decreasing material removal rates. Right-angle plunge grinding is used to machine bearing seats, shoulders and grooves. Angle plunge techniques may be more productive in certain applications.
- Transverse grinding is used for workpieces significantly longer than the width of the grinding wheel. The wheel moves parallel to the workpiece and is fed at right angles in several passes.
- Peel grinding is a variant of transverse grinding performed in a single, slow pass. CBN grinding wheels are well suited for the greater infeed rates typical of this process, as they offer the necessary strength at the edge of the wheel. This method is used in the production of transmission and drive shafts.
- Inside diameter (ID) grinding is used to refine bores with a high-precision fit. Grinding wheels, attached to a spindle shank, should achieve a cool cut with the lowest possible contact pressure and optimum free-cutting performance.
- Form grinding can be used to produce cylinders, cones, straight collars, chamfers and concave/ convex profiles in a single wheel mounting. This technique offers a high level of flexibility and fast rate of material removal.

Ordering Data for Wheel Types 1, 5 & 7



Face Shapes of Wheel Types 1, 5 & 7



Applications

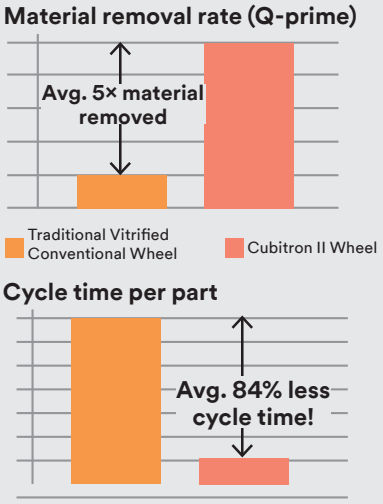
- Balance shafts
- Piston rings
- Turbine components and shafts
- Steering racks
- Fuel injection systems (pumps, injectors)
- Drive shafts

Recommended products

As with all grinding operations, the choice of abrasive depends on the specific application. A distinction is made here according to the HRc hardness classification.

3M™ Cubitron™ II Vitrified Wheels – for nitrided steel, tool steel, case-hardened steels and high speed steel (HSS).

OD Cylindrical Grinding: 3M™ Cubitron™ II Wheels vs. traditional vitrified conventional wheels



3M™ Vitrified CBN wheels

For hardened steels from 55 to 70 HRc. Ideal for high-speed automotive applications – particularly on modern materials that cannot be economically ground with conventional abrasives, such as powder metallurgical steel and high-alloy tool steel.

3M™ Vitrified wheels

For soft and hardened steel, case hardened steel and Inconel.

Centerless grinding

Because of its speed and relative economy, centerless grinding has traditionally been used for higher volume processing of cylindrical shapes. However, advances in both machine tool and grinding wheel technology have made centerless grinding a viable alternative for small and medium production runs, including those requiring tight tolerances and fine finishes.

3M offers a broad range of wheel constructions optimized for centerless grinding. We can also help you optimize your process with OPTIMA software, which provides realistic grinding and dressing parameters such as feed rates, infeeds, wheels speeds and more that can be directly employed in your CNC equipment.

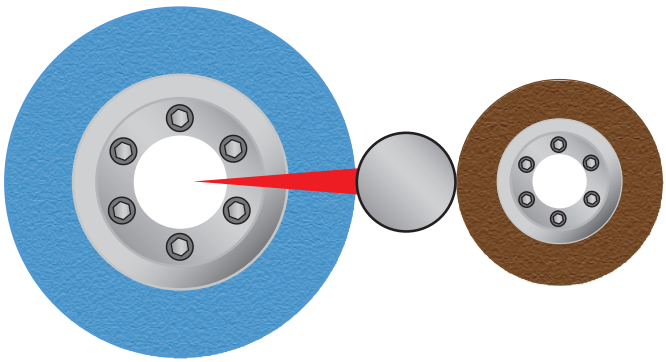
Recommended products

3M™ Cubitron™ II Vitrified Wheels
Ideally suited for use on carbon steels, tool steels and high alloy steels. Produces optimal results with high infeed rates, high grinding pressures and high material removal rates.

3M™ Vitrified and Electroplated CBN Wheels
Very cool cutting, for use on high alloy and hard steels from 55 to 70HRc.

3M™ Vitrified Wheels
High temperature resistance, for less cold welding of chips. Excellent on high alloy and hard steels, grey cast iron and non-ferrous metals.

Applications
- Piston pins
- Turbine components
- Valve/valve train



Microfinishing

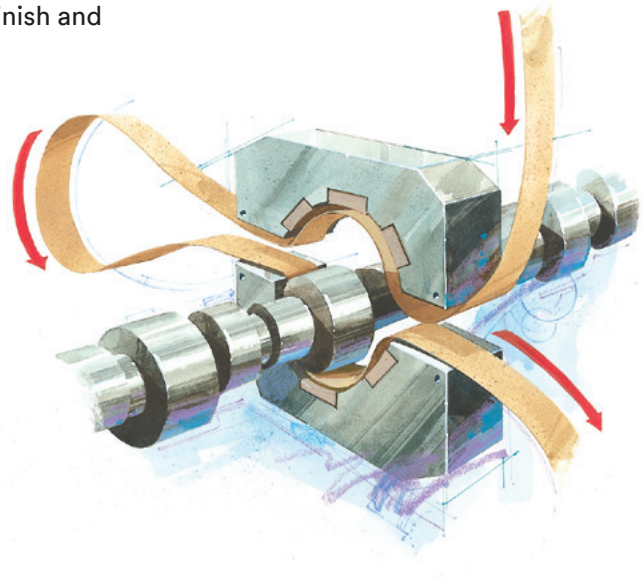
A microfinishing process employs rigid shoes to support the abrasive film. The workpiece, such as a crankshaft or a camshaft, is turned and oscillated between centers as 2shoes introduce the abrasive to the workpiece. Fresh abrasive is incrementally indexed after each part is processed, resulting in uniform stock removal and finish, part after part. Microfinishing removes the damaged or amorphous layers to improve the surface finish and roundness of the part.

3M™ Microfinishing Film

3M Microfinishing Film is a fast cutting abrasive that can produce consistent, predictable and repeatable high quality finishes. The abrasive particles are electrostatically oriented, then resin-bonded to a polyester film backing to give an aggressive cut with a uniform finish. Available in 9–100 micron grades.

Recommended products

3M™ Microfinishing Films
372L, 373L and 272L



Product	Mineral	Backing Caliper (0.001")	Backside	Grades (Microns)								
				9	15	20	30	40	50	60	80	100
372L	Aluminum Oxide	5	Type S	●	●	●	●	●	●	●	●	●
372L Type 2 (colored)	Aluminum Oxide	5	Type S		●	●	●	●		●	●	●
373L	Aluminum Oxide	5	Type Q	●	●	●	●	●	●	●	●	●
372L Type 2 (colored)	Aluminum Oxide	5	Type Q		●	●	●	●		●	●	●
272L*	Aluminum Oxide	5	Type S	●	●	●	●	●	●	●	●	●

* Available globally in wide rolls and belts

These films are color-coded by grade and feature side of roll printing and end of roll marking to reduce selection errors.

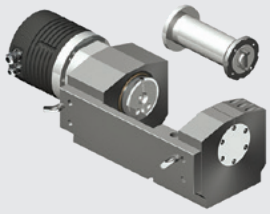
3M™ Dressing systems

3M develops and supplies precision dressing systems for all types of grinding machines. Dressing system quality has a determining influence on the efficiency and economy of the overall grinding process. For this reason, dressing systems require high-quality components in terms of both stiffness and precision. 3M dressing systems meet the highest requirements, whether for standard versions or custom built solutions.

Inline cantilever spindles

Outboard support dresser spindles

Quick change spindle arbors



Infeed dresser systems

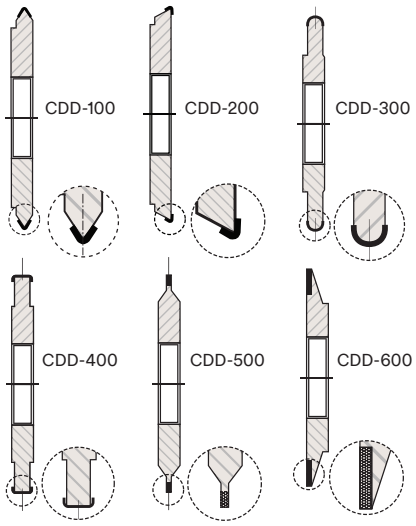
3M™ Stationary Dressing Tools

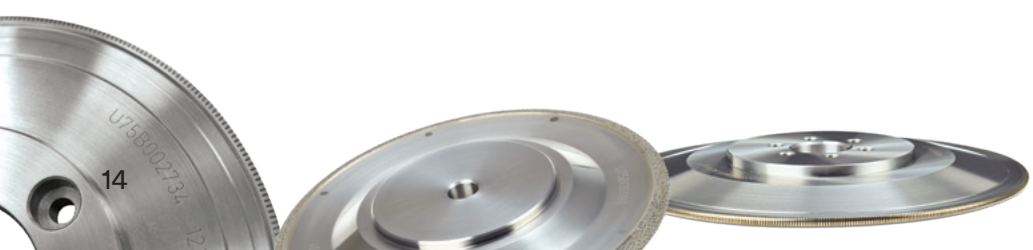
Natural diamond stone, set in steel shanks of various shapes. For straight or form dressing of conventional grinding wheels.

3M™ Rotary Dressing Discs

3M also manufactures a variety of diamond dressing discs for use on CNC machines, suitable for dressing conventional and superabrasive wheels. Available in diameters from 1" to 8".

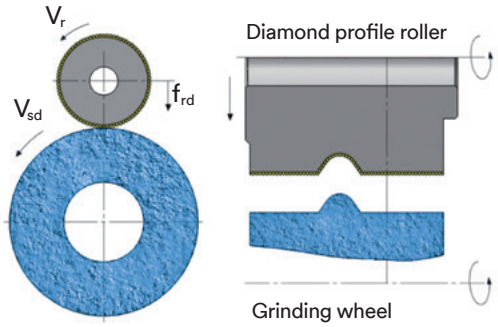
Rotary dressing disc popular shapes





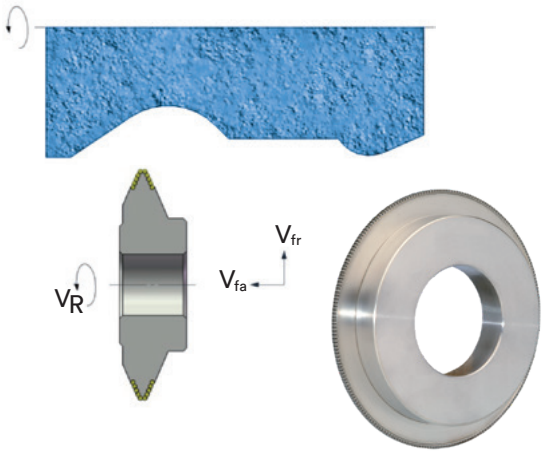
3M™ Diamond Profile Dressing Rollers

- To shape grinding wheels in the shortest possible time
- Profiling of the grinding wheel in only one operation using the plunge-cut dressing method
- Extreme accuracy, even with highly complex profile contours
- Highest cost-effectiveness



3M™ Diamond Form Dressing Rollers

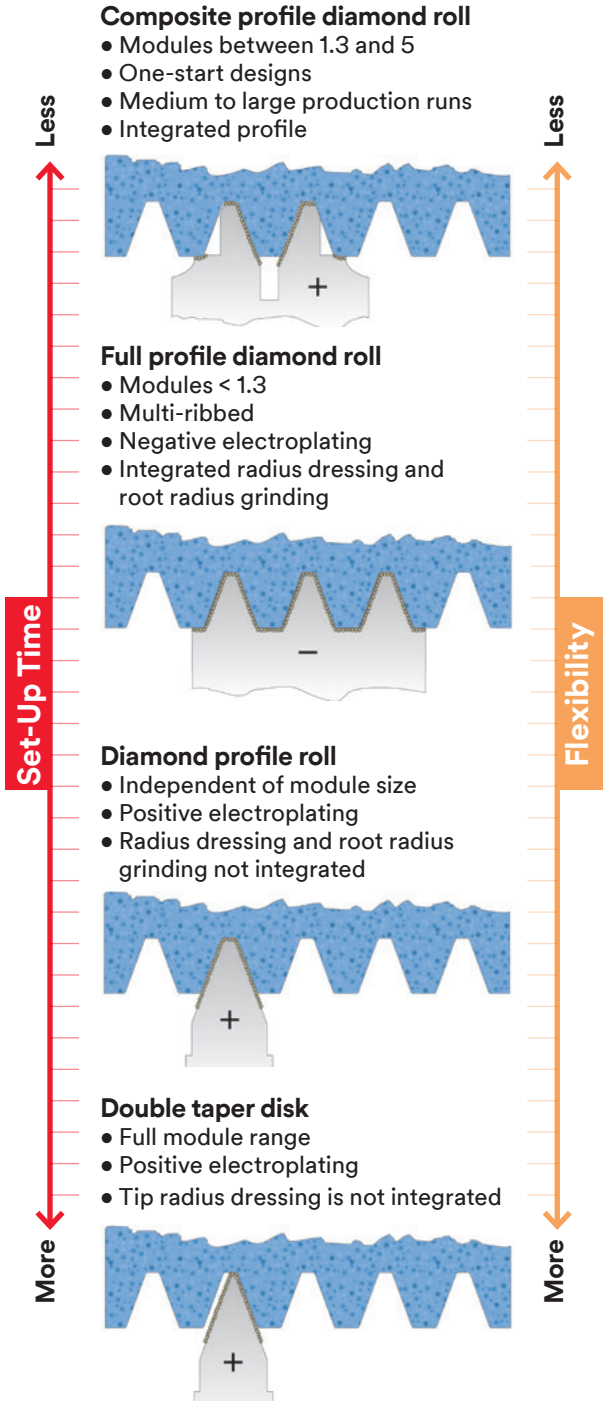
- Profiling of the grinding wheel along the desired contour by moving the diamond dressing roller
- Extreme accuracy for simple and highly complex profile contours
- Highest cost-effectiveness



Flexibility vs. set-up time

In general, every dressing technique involves a compromise: the more time spent during set-up, the more flexibility you have during operation, and vice-versa.

This graphic illustrates some typical tradeoffs between set-up time and flexibility offered by some common dressing methods:



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