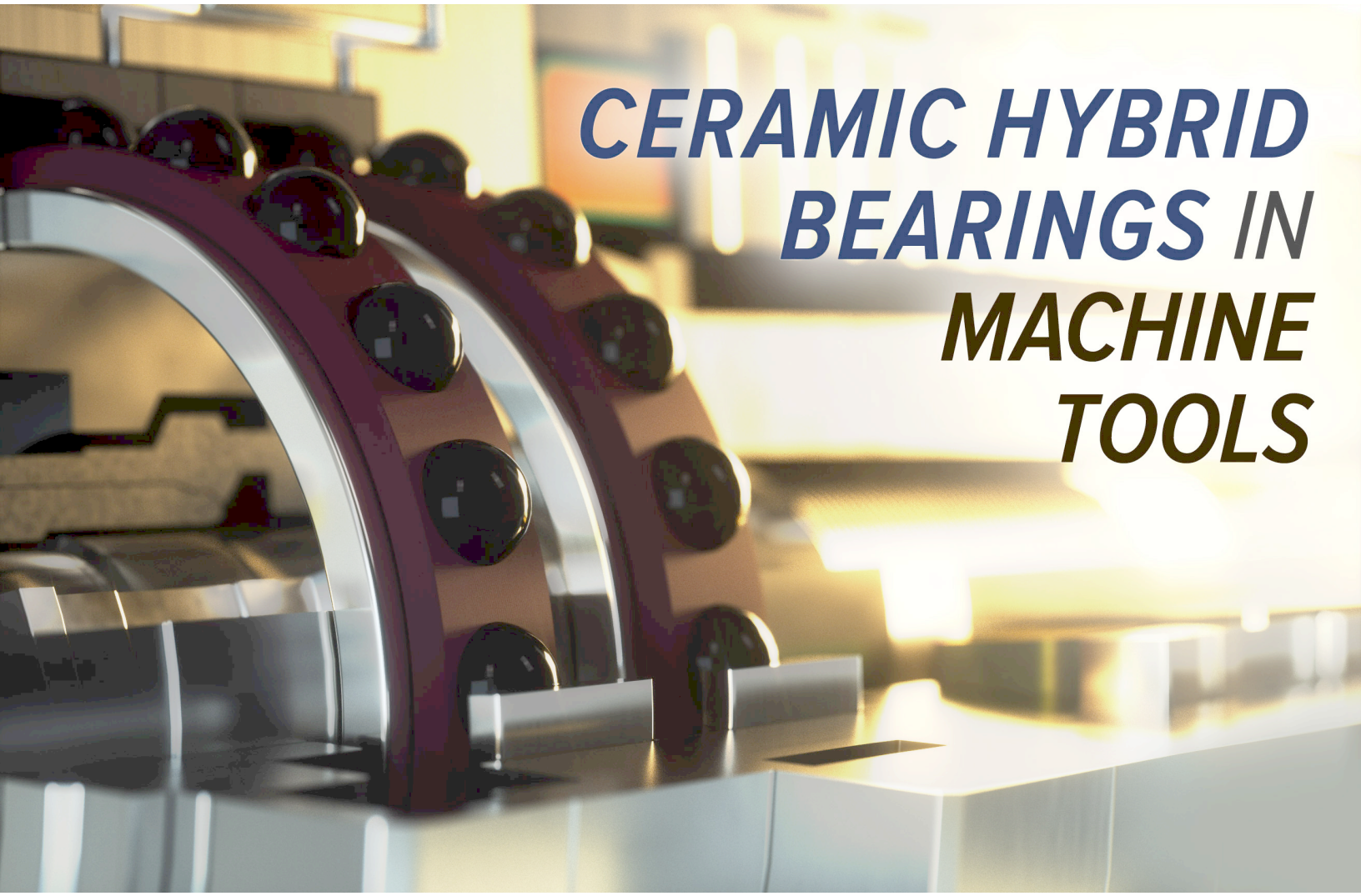
BOCA BEARING COMPANY
1420 Neptune Dr. Suite A
Boynton Beach, FL 33426 U.S.A.

Phone : (800) 332-3256
Fax : (800) 409-9191
Email : info@bocabearings.com

BocaBearings
PRECISION CERAMIC TECHNOLOGY



CERAMIC HYBRID BEARINGS IN MACHINE TOOLS

THE CRAFT OF CERAMIC BEARINGS

If an application involves rotating machinery, there is a near-definite probability that bearings are being utilized. In the simplest of terms, bearings are mechanical supports that allow free rotation, while at the same time limiting axial and perpendicular movement. The use of bearings ranges from recreational applications—think fishing reels or radio-controlled (RC) cars—to highly demanding applications, such as power generation and high-precision machining. In each case, the bearings selected for use must be designed to withstand the operating conditions to which they will be exposed.

The two main elements of a bearing are the balls that allow for rotational motion and the rings that hold them in their track. Bearings can be manufactured either from steel or from high-performance ceramics, which leads to three possible combinations:

- Full Steel Bearings = steel rings and balls
- Full Ceramic Bearings = ceramic rings and balls
- Ceramic Hybrid Bearings = steel rings and ceramic balls

In general, full-steel bearings have the lowest cost but also the shortest service life, especially in high-speed and high-temperature applications. Full-ceramic bearings are ideal for any extreme environment that requires non-corrosive, non-conductive or non-magnetic bearings; and while they have the longest service life, they also cost up to seven times more than steel bearings. And then there are ceramic hybrid bearings—offering a balance between cost and performance, as they last a minimum of twice as long as full-steel bearings (and often much longer)—at roughly just twice the cost of full-steel bearings they can balance that ratio of performance to cost.

CERAMIC HYBRID BEARINGS FOR HIGH-SPEED APPLICATIONS

Ceramic hybrid bearings offer many performance advantages over their metallic counterparts. In addition to meeting the demands of high-speed machine tools—in which conventional metallic bearings suffer from rapid deterioration—ceramic hybrid bearings also are used in special applications, such as magnetic resonance imaging (MRI) scanners. The following table summarizes the advantages of ceramic hybrid bearings:

Benefit	Description
Stiffness	Ceramic hybrid bearings have a higher stiffness than metallic bearings, and this brings two advantages: higher precision and reduced vibration. • Higher precision leads to increased product quality in machining processes, since the spindle is displaced less from its central position. • The reduction in vibrations extends the service life of all machine tool components. Since propagated vibrations are less impactful, sensitive mechanical components last longer. In addition, reduced vibration also increases machining quality.
Higher RPM	Assuming the same ball diameter for a steel bearing and a ceramic bearing, the ceramic balls have 60 percent less mass. This reduces centrifugal forces and wear, allowing operation at 30 percent higher speed.
Longer Service Life	As previously stated, ceramic hybrid bearings can last more than 200 percent longer than metallic bearings. The use of ceramic balls and steel rings prevents a process called cold welding, which causes surface deformation when steel elements are in contact at high speed.
Thermal Stability	Compared with steel bearings, ceramic bearings expand less with high temperature. This means that stiffness and performance are maintained over a wide range of operating temperatures.
Corrosion Resistance	Unlike steel, ceramic materials are not susceptible to corrosion.

SEEKING HIGH PRECISION FOR MACHINE TOOLS? SEEK CERAMIC HYBRID BEARINGS

Indeed, machine tools exist to cut, bore, shear and grind metal (and other rigid materials). The fact that the cutting tool is controlled by machine—rather than by human direction—means it provides extreme precision that one would not obtain by simply cutting "freehand." And with machine tools powered either electrically, hydraulically or via line shaft, those bearings that enable rotation are a key component to a machine tool's economical production of interchangeable parts.

Consider that a machine-tool spindle must provide high rotational speed—and transfer torque and power to the cutting tool—while also having reasonable load capacity and life. And with criteria like temperature ranges and maximum revolutions per minute (RPM) serving as factors in selecting the proper bearings, full-ceramic angular contact bearings are the most typical type of bearing used for high speed spindles. Why? Because they feature the ceramic balls that allow the spindle to achieve up to 50 percent more RPM; they dissipate heat quicker; and they have a much lower rate of thermal expansion.

The end result is that ceramic hybrid angular contact bearings offer distinct advantages over typical full-steel bearings: phenomenal precision, load-carrying capacity (both axial and radial when preloaded) and the speed needed for cutting metal.

THE DN NUMBER: A BENCHMARK FOR HIGH-SPEED BEARING PERFORMANCE

The dN number is a metric used to describe the speed performance of a bearing, and it is calculated by multiplying bearing diameter (in millimeters) and rotating speed (in revolutions per minute). With both factors at play, it's worth noting that a 10-mm bearing rated at 20,000 rpm, and a 20-mm bearing rated at 10,000 rpm, both have a dN number of 200,000.

In high-speed applications such as machine tools, the dN number specified for bearings must reach values of as high as 1,500,000. As such, because steel bearings typically have a dN number below 1,000,000, they cannot be used reliably in high-speed applications. Ceramic hybrids, however, as offered by Boca Bearings have a dN of up to 2,000,000, making them suitable for these highly demanding applications.

THE INDUSTRY AUTHORITY: ABEC

All precision bearings manufactured in the USA must meet the standards published by the American Bearing Engineers Committee (ABEC). These are the standards accepted by the American National Standards Institute (ANSI), which are equivalent to those from the International Organization for Standardization (ISO).

ABEC standards include an accuracy scale for bearings, which ranges from ABEC 1 to ABEC 9. The ABEC 1 rating is for general-purpose bearings in applications where high precision is not required, while the absolute optimum ABEC 9 is an actual military-grade bearing.

THE INDUSTRY AUTHORITY: ABEC ...CONTINUED

"Boca Bearings products are unique in that they are available in accuracy ratings up to ABEC 7," said Flanzbaum, "which are considered the highest tier in non-military applications." He added that 80 percent of the Boca Bearings market is composed of general purpose applications not requiring the highest of precision, with the remaining 20 percent demand composed of specialty high-end applications such as turbomachinery and high-speed machine tools.

GENERAL RECOMMENDATIONS FOR SELECTING MACHINE TOOL BEARINGS

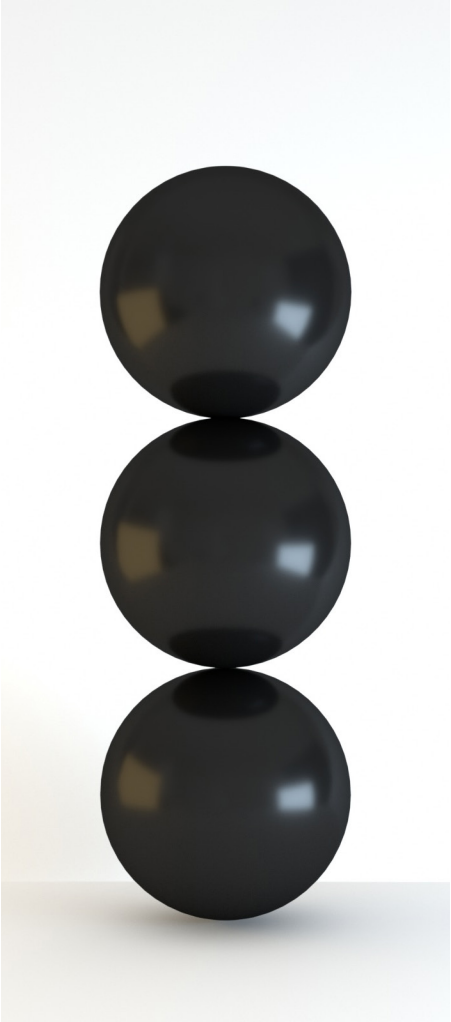
When selecting bearings for machine tools, it is important to understand there are two types of stiffness: radial and axial stiffness.

Radial stiffness is resistance to movement that is perpendicular to the spindle, and it increases as the bearing contact angle decreases. For example, milling demands a high radial stiffness because the main load is applied perpendicular to the spindle.

Axial stiffness is resistance to movement running horizontal to the spindle, and it increases as the bearing contact angle increases. For example, drilling demands a high axial stiffness because the main load is applied along the spindle.

Bearings can be preloaded to increase stiffness, but keep in mind this reduces the speed and shortens service life. As a result, over-specifying the stiffness of bearings is not recommended. Conversely, ceramic hybrids from South Florida-based industry leader Boca Bearings are designed for ease of replacement in existing machine tools because they can be ordered and replaced based on the exact size and part number for which the tool calls.

Also of note: While Boca Bearings currently conducts 30 percent of its business operations through third-party distributors, the company also offers custom-engineered bearings for special applications. Said Flanzbaum: "We have recently added an engineer with 30 years of bearing design and manufacturing experience to our staff to further help companies with their bearing and motion control design and troubleshooting needs."



NEXT LEVEL: ENHANCING BEARING PERFORMANCE VIA HIP MANUFACTURING

HIP stands for "Hot Isostatic Pressing." During the HIP process, ceramic powder is formed into the desired shape at high temperature and pressure, which minimizes surface defects and porosity. Thus, when the ceramic balls for a bearing are manufactured with the HIP process, they achieve a higher density and hardness than standard ceramic balls, increasing their fracture resistance significantly.

HIP CERAMIC VS GPS CERAMIC

				GPS	HIP
Density			g/cm^3	3.25	3.25
Water Absorption			%	0	0
Mechanical Characteristics	Vickers Hardness (Load 500g)		Gpa	14.5	**15**
	Flexural Strength		Mpa	700	**1000**
	Compressive Strength		Mpa	3200	**3900**
	Young's Modulus of Elasticity		Gpa	310	310
	Poisson's Ratio		-	0.28	0.28
	Fracture Toughness		$Mpa{\cdot}m^{1/2}$	6-7	**7**
Thermal Characteristics	Coefficient of Linear Thermal Expansion	40~400°C	$*10^{-6}/°C$	3.5	3.5
	Thermal Conductivity	20°C	W/(m·K)	23	23
Electrical Characteristics	Volume Resistivity	20°C	Ω·cm	$\geq 10^{14}$	$\geq 10^{14}$
	Dielectric Constant (1MHz)		-	-	-

COST-EFFECTIVE CERAMICS

To reiterate, while ceramic hybrid bearings cost twice as much as full-steel bearings, the cost per hour of use is comparable, and usually superior, because their service life extends at least twice as long as full-steel (and often much longer). Also consider that bearing replacements are required much less frequently on ceramic hybrid bearings, thus providing savings via both maintenance man-hours and in avoiding machine tool "downtime." So despite a slightly higher up-front cost, it's fairly certain to conclude that ceramic hybrid bearings have a lower ownership cost than do full-steel bearings.

Questions about ceramic hybrid, full-ceramic or full-steel bearings? Find lots more information via the Boca Bearings Website, where visitors will also find a free-of-charge "live help" chat option.

BOCA BEARING COMPANY
1420 Neptune Dr. Suite A
Boynton Beach, FL 33426 U.S.A.

Phone : (800) 332-3256
Fax : (800) 409-9191
Email : info@bocabearings.com

BocaBearings
PRECISION CERAMIC TECHNOLOGY