MOUNTAIN BIKE ACTION AUGUST "07"

CERAMIC BEARINGS 101

Will they make you faster?

Mention the word ceramic 50 years ago and you would have thought of dad's Beatniks coffee cup. Nowadays a ceramic is any inorganic, non-metallic material which, like the Beatniks cup, was formed by the action of heat. The ceramic part of ceramic bearings is made out of silicon nitride. It's a man-made compound that is synthesized through several different chemical reaction methods. Hot pressing the silicon nitride under extreme pressure produces a very hard, lightweight material of near zero porosity. Silicon nitride Si3N4 was developed by the aerospace industry back in the 1960s (just as dad was moving on from the Beatniks to The Beatles.) the intent was to find a high-strength material that would outperform steel. Si3N4 balls are widely used in high-precision bearings in turbine engine, high-speed machine tools, finite measurement instruments, mechanical centrifuges, radar, missiles, pumps, compressors and especially anywhere excess bearing heat due to high shaft speed is an issue.

BENEFITS OF CERAMIC

"Ceramic," by its very nature is: 1) Lighter than steel, about 2/3 the weight. 2) Harder that steel in ball form, about twice the Rockwell hardness. As a ball it is the third hardest material known to man, following diamond and cubic boron nitride. 3) Nonporous. A steel ball, in comparison, looks like the surface of the moon when magnified. Ceramic's glass surface is what accounts for the lower coefficient of friction and 50 percent more rpm. 4) Non-corrosive. It is not an oxide, so it won't rust. 5) Very resistant to wear and abrasion. 6) Resistant to deformation under load. The balls stay rounder when impacted. 7) Resistant to thermal expansion. The sphericity of the ball is not affected by heat. Another benefit is that ceramic bearings do not need lubrication, although the bearing still needs to be lubed to protect the steel races that the ceramic balls ride in.

FROM TURBINES TO TOUR de FRANCE

Right now, ceramic bearings are considered hybrid bearings because only the bearing balls are made out of ceramic material. Back in 2001, Zipp was the first cycling company to begin experimenting with ceramic bearings. They used the finest Grade-2 ceramic bearing balls available. They say that each is over 1000 times more round than the best steel bearing ball, and that a matched set has a variance in size and sphericity of less than 2 millionths of an inch. The spin rating is claimed to be 300,000 rpm, compared to 33,000 for their finest steel ball bearing. Zipp claims that their bearings have won Olympic medals, more than 20 Tour de France stages, World Championships, and Grand Tourd with the ceramic-equipped bikes.

WHY NOT FULL CERAMIC?

There are bearings available that are completely ceramic, both the balls and races. They are used in high-speed vacuum motors and acid bath equipment. The problem with the ceramic material is that once it is formed into an open ring, like a bearing face, it

becomes brittle. A full-ceramic bearing could not be press fit into a hub shell, for example. The outer ceramic race would break when compressed. Even if it were bonded in place with epoxy, the brittle nature of ceramic races would not be able to handle sharp impact loads. Both the inner and outer races would be pulverized within a day. A full ceramic like this would cost seven times as much as a standard steel bearing and twice as much as a hybrid ceramic bearing.

FROM FRANCE TO FONTANA

"We discovered them by mistake," jokes FSA's Ric Hjertberg. "The mecanics for the CSC road team were taking our bearings apart to replace the steel balls with ceramic balls, so we looked into it for ourselves and saw that for the elite cyclist there is a huge gain in performance. We mastered the technology ourselves and started offering it for our road components first. Now the technology is filtering into the elite mountain bike scene. Multi-World-Champion Gunn-Rita Dahle is riding them now." Continues Ric, "The ABEC rating doesn't give you the smoothness of the races at all; just dimensional uniformity. The higher the ABEC number is generally the better bearing. But it's not a guarantee. It's like saying someone with lower body fat will be a better rider. But no all skinny people are good riders. The ABEC rating is not a regulated number.

HOW BEARINGS ARE RATED

The ABEC scale is a system of rating the manufacturing tolerance of precision bearings. The system was developed by the Annular Bearing Manufactures Association. Bearings rated under the ABEC system are typically called "precision bearings," with a rating or class from 1 to 9. ABEC 1 meets a looser range of tolerance on bearing dimensions, while ABEC 9 meets a very high precision bearing tolerance. Bearing tolerance is a measurement of the OD, ID and thickness of the bearing. The ABMA also has a set of grades for bearing balls. Bearing balls are measured with very accurate machinery to determine if they meet the required tolerances. A grade three ball has to be spherical within three millionths of an inch, and the diameter must be accurate within 30 millionths of an inch. This means that for a grade three quarter-inch ball, the diameter would have to be between 0.24997 and 0.25003 of an inch, and the smallest diameter measured on the ball has to be within three millionths of the largest diameter. The average human hair is three thousandths of an inch (0.003) thick. The lower the grade number, the more spherically perfect a bearing ball is. Finally, we have bearing fit. Bearing fit measures the internal clearance between the races and the ball. This is the play you feel when you grab the inner race between your thumb and index finger and rock the outer race back-and-fourth axially with the other hand. The clearance, or fit of a bearing is denoted by the bearing number suffix C3, C4, C5 and so on. A bearing with no "C" suffix is a bearing with normal clearance. A C3 bearings is slightly looser than normal, and a C4, C5, etc. would have looser and looser fits. Any bearing sold to the bike market comes in a C3 fit. The slight bearing play compensates for the thrust loads placed on a bearing from tightening quick releases and bottom brackets.

BEARING MATERIAL

Steel bearings will be completely made from either 52100 chrome steel or 440 stainless. Chrome steel is slightly harder, less expensive, and not as preferred in a cycling

environment due to moisture contamination. The only real disadvantage of the stainless material is that if a contaminant gets in the bearing, it can pit the race more easily than with chrome steel. You will hear some manufactures tout that their bearings are especially heat- or cryogenically-treated (freezing). All chrome steel and stainless steel bearings are heat-and cryogenically-treated; it's part of the formation process. Both processes align the molecules to give the metal a tougher quality. Other than corrosion, there is no performance difference between chrome steel and stainless steel bearings. You can turn each one into a better performing hybrid bearing by replacing their respective bearing balls with ceramic balls. It just makes more sense to use stainless races with ceramic balls for the utmost in durability.

WHAT ABOUT BEARING CAGES?

The bearing cage keeps the balls consistently positioned in and around the circumference of the bearing races. Without cages, the balls would collect together on one side of the bearing and would develop too much radial play. Also, if the balls are allowed to contact each other, it creates friction. Bearing cages can be made from nylon, steel or polymite. Steel races are commonly made from two halves that are riveted together to sandwich the ball. A ribbon cages weaves in and out of the balls to hold them in position, and crown cage clamps around each ball. All types of cages can be found on ceramic hybrid bearings as well as chrome and stainless steel bearings. Polymite and nylon cages are generally preferred because of their lightness and pliability.

THE EXPERTS TELL

BOCA BEARINGS ON EASY-TO-AFFORD CERAMICS

-Boca Bearing is a company that specializes in miniature bearings for industry, radio control hobbies, and recreation. Explains Jason Flanzbaum. "About four years ago people started asking to put ceramics into their mountain bikes. Boca Bearings felt that we could offer a bearing that would still achieve all of the beneficial properties of ceramic- lighter, harder, faster- but without the expense of the aerospace-quality bearings." "A common ceramic bearing for the bottom bracket is a 6805, which is capable of achieving 30,000 rpm," explains Jason. "Boca's take is that this speed is simply never achieved on a bike. So the realized benefit of higher grades and better tolerances is normal at best and certainly targeted at only the most serious of professional riders who have a great deal at stake in each fraction of a second. Foe everyone else, there is our more affordable ceramic option." "Bearing speed and bearing longevity is a never-ending push-and-pull battle. Every time you add a shield or a seal to keep out the dirt and water, or add grease for more protection, the resistance goes up and the bearing slows down. Because of this, Boca Bearings offers three types of Lightning Series hybrid ceramic bearings."

ULTRA SEAL CERAMIC BEARINGS: Maintenance free lubed-for-life bearings designed for road use in a relatively clean riding environment . They use a non-contact seal underneath a metal shield to cut down on the drag typically associated with rubber sealed bearings.

YELLOW SEAL CERAMIC BEARINGS: These are designed specifically for mountain bikes and excessively dirty environments. A heavy duty contact rubber seal

provides extra protection. They are also maintenance free and lubed for life. These bearings require a longer break-in than the Ultra Seal types.

ULTRA DRY LUBE CERAMIC BEARINGS: Some velodromes cyclists like to run their bearings dry and without seals or shields. We take a Lightning Bearing, remove the seals, thoroughly clean out the grease, and treat it with our tungsten disulfide Ultra Dry Lube. It creates the fastest bearing known to man, but one that is completely open to the elements. There is an up charge of $15 to $30 to Ultra Dry Lube any size Boca hybrid ceramic bearings.

Let's take a look at the price difference between the bearings that Boca offers to replace the 6805 bottom bracket cartridge size:

CHROME STEEL BEARING: ABEC 1 rating, Grade 10 ball, chrome steel races, chrome steel cage: $22.

STAINLESS STEEL BEARING: ABEC 1 rating, Grade 10 ball, stainless steel races, stainless steel cage: $47.

LIGHTNING SERIES CERAMIC HYBRID BEARING: ABEC 1 rating, Grade 10 ball, stainless steel cage races, stainless steel cage: $59.

PREMIUM SERIES CERAMIC HYBRID BEARING: ABEC 5 rating, Grade 5 ball, stainless steel races, polymite cage: $74.

POINT-COUNTERPOINT

THE EXPERTS RATE CERAMIC BEARINGS

American Classic's Bill Shook: "Foe us it's an upgrade option. At 199.95 to upgrade the six bearings in an AC hubset to ceramics is very expensive. We use ABEC 5 rated bearings with ceramic balls and stainless races. You do get something out of the ceramic upgrade. The riders swear they can tell the difference. They say they notice how much easier the wheels roll. Most of the feed back I've gotten has been on a road bike. If it's noticeable on the road, it's going to be the same off-road, although the gain will be masked by the other aspects of riding off-road. Ceramic bearings were originally developed for high-speed applications where heat is a problem. A bike wheel spins much slower than this. However, I've got my theories on why they work so well on a bicycle. It might be low speed, but a much higher load. The bearing is punching through the grease layer and contacting the steel races. On steel against steel, the bearing welds to the race. With ceramic balls there is none of the micro-welding that causes steel balls to stick to the races. That's why ceramic bearings are faster. To save weight, bicycles use smaller bearings with fewer balls. The grease is getting completely squeezed off the balls when they contact against the race. That's what caused the bearings to rust and seize on the older AC hubs. As soon as we switched to stainless steel bearings, the problem ceased. Stainless can handle impact loads better because it doesn't corrode. That's why stainless races with ceramic balls makes a lot of sense."

Shimano's Devin Walton: "We are not ignoring ceramic bearing technology and have been testing hybrid bearings since the day they hit. Shimano still isn't convinced that the benefit will ever surpass the cost pitfall for most riders. Yes, the decrease in friction can create a power savings. But we're talking 10ths of a kilowatt here. The bearings spin insanely free by themselves, but you have to add in seal drag if the bearing is to be used in the real world. Maybe a lightly sealed bearing would make sense for an

elite cyclist on the fringe of very high performance. But these guys also service the bearing every ride. Riders at the grassroots level don't even service bearings once a year! Also, the weight savings is negligible. Switching every steel bearing with a ceramic bearing is the same weight savings as taking three quarters out of you pocket. For all of this you are paying 100 to 150 percent increase in component cost. If we see it as enough of a value at a super exotic level, the maybe we'll employ it."

Chris Cocalias, founder of Titus: "I replaced the stock Titus Racer X steel bearings with ceramics. After three rides the bearings were shot. I've never had a pivot wear out as fast as that."

Dave's Wheels' Dave Thomas: " one has to ask himself, how much faster are these ceramic bearings? People are spending a lot of money to save three seconds in a one hour time trial. You would be better off spending the money on chiropractic care. It looks like the standard steel bearings in most hubs are better quality. Most bicycle companies shoot for ABEC1 to 3 bearings. Remember, the ABEC rating is just the tolerance rating of the bearing. The lower ABEC bearing seems to work better in a bicycle. It help compensate for out-of-alignment issues when the quick release gets tightened. Plus, the bearing rating doesn't speak of the seal or grease., both of which have more to do with how well the wheel spins. It's a tradeoff. A steel bearing with lower contact seals can offer as significant a performance gain as ceramic balls. Lightly sealed bearings, unfortunately, don't last as long. Everyone is very hyped up on ceramic bearings. It is going to take at least $100 more to upgrade hubs to the lower cost ceramic bearings. German-made ceramic bearings will take $300 to swap out. I just did a set of tandem wheels with ABEC 5 ceramic bearings. They didn't feel as good as the stock steel bearings. On top of that, I have heard reports of the ceramic bearings failing after a few months. I feel that many of the companies are using ceramic bearings with low contact seals so that the bearing feels like it spins faster."

NoTubes' Stan Koziatec: " No matter how good you make the bearings, the moisture will get in there. Two years ago we tried ceramic balls with standard races. The riders tore them up after only a few weeks. It wasn't even worth the bother. We're sticking with stainless steel bearings that American Classic uses. Specialized and Kenda-Seven Cycles ran my wheels all last year (which use AC hubs), and even in the extremely muddy conditions at Sea Otter and at two of the World Cups, we didn't have one bearing failure. Geoff Kabush still has the original bearings in his NoTubes wheelset. As soon as moisture gets in there and pits up the race, the advantage of the ceramic balls means nothing. It's a waste of time and money. I believe that the proper care and maintenance of a standard bearing is much more important and will make the biggest difference in performance."