Cyrol – Ceramic Rollers for Bearing Applications

Ceramic balls in what are known as hybrid bearings and even full ceramic bearings reflect one of the latest technological advances in industrial applications today. So far, this bearing concept with ceramic balls could not be transfered to roller bearings. Now, CeramTec has developed materials and processes to offer ceramic rollers branded Cyrol for a new generation of roller bearing systems.

Fig. 1
Silicon nitride bearing rollers

Roller bearings with ceramic ball elements have established themselves as state of the art bearing systems. This is not only due to the technical advantages afforded by these bearings, but also the dramatic drop in prices seen several years ago. Their reduced price made these ball bearings an excellent value and enabled users to replace common steel ball bearings with hybrid bearings. Ball bearings with ceramic elements are far superior to traditional bearings, particularly in a select number of usage scenarios. Benefits include lower friction, longer bearing and lubrication life, better performance at higher speeds, improved electrical insulation, etc.

Cylindrical roller bearings, however, have been unable to replicate this success. In most cases, production costs of ceramic rollers were too high to convince users of their technical benefits. Now, *CeramTec* has developed material and processes to offer silicon nitride bearing rollers branded Cyrol with an excellent cost-benefit ratio at high quantities.

The geometries range from cylindrical and tapered all the way to spherical rollers, fulfilling needs and demands of the bearing industries, which in turn are responding to ever growing requirements from high-end markets.

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Why use ceramic rolling elements?

There are few compelling reasons to replace steel bearings with hybrid bearings in a system that is running properly, as the costs for hybrid bearings will always be higher. However, ceramics are worth considering in applications that require frequent maintenance or in situations where technical issues cannot be resolved due to the properties of common bearing materials such as steel and other metals.

Silicon nitride has been identified as a material that delivers most of the properties required for rolling applications, including balls and cylindrical bearing rollers.

There are myriad technical reasons for using silicon nitride rolling elements:

- High wear resistance
- Chemical resistance
- Temperature resistance
- Low friction
- Non-magnetic
- Low specific weight
- Longer life-time
- Good dry running performance and, consequently, improved emergency operating features
- High electric resistivity.

All of these properties offer opportunities for creating new industrial applications and reducing maintenance costs for machinery.

They also enable a number of applications that were impossible to implement until now.

For example, only the electric resistivity combined with lower friction and therefore prolonged lifetime help refine generators and electric power trains, whereas the higher initial costs of a hybrid bearing begin to pay off immediately.

The actual material properties, such as the low Young's modulus and corresponding rigidity result in a lower operating temperature, which in turn has a positive effect on lubrication lifetime and even the connected structure of the machinery.

In hybrid bearings the different materials of rolling elements and rings result in a low affinity and thus in reduced breakaway torque following longer periods without use. Silicon nitride exhibits electrically insulating behavior. This eliminates the effect of electro-pitting caused by electrostatic charges or dynamic charge reversal as the (very high) dielectric strength limits of the material are reached.

Possible fields of application

Taking all aspects of mechanical systems into consideration, there are a number of industries that might benefit from recent advances in ceramic roller bearing development.

This applies to all of the industries mentioned above and those that use generators such as wind energy plants or seawater-based energy production, along with other industries, including printing machinery, textiles, chemicals, mining, high speed spindles or even electric powertrains in cars and trains. This is only a partial overview of the fields of application that are now opening up to engineers and developers. In all of these instances, one or more of silicon nitride ceramic's properties when used as a roller bearing could at least prolong service life or make the application feasible in the first place. And cylindrical or tapered rollers will be implemented wherever balls are unable to satisfy mechanical demands.

Meeting material and geometry requirements

The technical standards for silicon nitride bearing rollers are specified in ASTM F 2370/F 2370M, which is used to classify the rollers according to their material and geometrical properties. Assuming that only class I, the highest grade, is found in mid-range and high-end solutions for bearings, this is the only method of obtaining approval from bearing manufacturers.

For the production of ceramic rollers, CeramTec wanted to have control over the full depth of production, from the spray drying process to the finished product. So every step of the process had to be reviewed.

Once development was completed, the newly designed silicon nitride material SL900 not only met, but actually exceeded the highest specifications. For example, there were no relevant inclusions and the material exhibited a porosity of <10 µm and a bending strength of >765 MPa. This material also satisfied all of the microstructural demands placed on it.

The material has already received approval from the bearing industry.

Ceramic bearing roller design was inspired by the geometrical aspects of metal rollers. In many cases, the bearing manufacturers – and a number of their customers – want the option to simply replace existing cylindrical or tapered bearing rollers made from metal. One example of this is simply copying the shape of a metal roller and applying it to a silicon nitride roller. The development process needs a fresh approach to designing and optimizing new bearing systems with ceramic elements. The key is to consider the material properties in their entirety, not only using them as replacements but also as ideas that serve as a catalyst for downsizing bearings or bringing other concepts to fruition. Many companies and universities are already making their first forays into this field of research, but there has not been a receptive market until now. This will change in very near future.

Fig. 2
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Obviously, ceramic bearing rollers are subject to the same demands as metal bearing rollers when it comes to the roundness and waviness of the lateral surface. Both of these properties are essential for proper bearing operation and reducing running noise.

Specifications governing dimensional deviations are much stricter for ceramic rollers than for many other ceramic products. What follows is a brief example (according to ASTM F2370):

- Bearing roller, with a very common size of 12 mm in diameter and 12 mm in length: roundness <1,15 µm (today's customer requirements: <1 µm)
- Straightness of cylindrical area, convexity: <1,0 µm

- Lot variation diameter: 2 µm (today's customer requirements: 1 µm)
- Lot variation length: 8 µm (today's customer requirements: 4 µm).

All of these limiting values must be maintained simultaneously. Bearing in mind the common means that ceramics manufacturers use to produce these types of parts, it is hardly surprising that this method is expensive and therefore rarely the first choice for users seeking alternative solutions. By improving existing processes and developing new ones, CeramTec is now also able to meet and exceed the specifications required to produce silicon nitride bearing rollers in the field.

As a result of these efforts, all of the processes – from the powder to the finished product – are now available from a single source. The advantages for end users are obvious. All of the required expertise can be found in one location: from powder technology to raw part production to grinding. Specialists are available to answer any questions customers may have and the company offers a full range of one-stop services. The clear aim of providing "standardized" shapes to a number of users, combined with the ability to produce high-volume, customized solutions offer a fresh approach to lean, effective production methods.

Meeting the market's expectations

CeramTec has spent a lot of time and effort developing new processes for producing silicon nitride cylindrical bearing rollers at an excellent value. The company aimed to repeat the success of ceramic balls and shifting the focus of the bearing industry to the availability of ceramic rollers, which urgently needs these bearing rollers in order to satisfy the demands of a rapidly growing, high-end market. Here, service life and material properties are key and ceramic rolling elements are the only products available on the market that can deliver these performance-enhancing features.

To meet this demand, CeramTec launched a new production line to manufacture ceramic rollers that meet the highest demands in terms of materials and geometrical requirements. One of the reasons these rollers deliver such excellent value is very simple: The production line is designed for medium and high volumes and does not commit to single parts handling. Production line machinery, quality and testing equipment is cutting edge technology, which enables the same fast and effective process and product control.

The cylindrical rollers are sorted in diameter and length based on customer requirements and the necessary quantities, so silicon nitride rollers are truly a ready-to-use product.

CeramTec is already able to produce Cyrol bearing rollers in a number of different shapes, from cylindrical rollers to tapered rollers. What's more, spherical rollers are scheduled to complete the product range in the near future.

All shapes not only meet but actually exceed the bearing industry's highest requirements, which is why we can expect to see these products in an increasing number of applications in the future.