

Bearing issues account for 51% of all electric motor failures. However, the U.S. Department of Energy estimates that the number is closer to 67%.

Electrical Arcing Damage

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(Extends Lube Life)
Lower Friction
(Energy Saving)
Dramatically Longer Life**



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White Paper: Why Hybrid Ceramic Bearings Excel Over Traditional Steel Bearings in Motor Applications

Abstract:

This white paper explores the benefits of hybrid ceramic bearings' performance, durability, and efficiency compared to traditional steel bearings in motor applications. By examining key factors such as thermal performance, wear resistance, and operational lifespan, we highlight why hybrid ceramic bearings are increasingly becoming the preferred choice for engineers and industries seeking reliability and superior performance in demanding motor environments.

Introduction:

Bearings are integral components in motors, enabling smooth rotational motion while minimizing friction and wear. Traditional steel bearings have long been the standard choice due to their affordability and mechanical strength. However, as motors operate at higher speeds, temperatures, and precision demands, hybrid ceramic bearings have emerged as a superior alternative. These bearings combine steel races with ceramic rolling elements, providing a unique blend of material properties that offer unmatched performance in critical motor applications.

Advantages of Hybrid Ceramic Bearings:

1. Reduced Friction and Heat Generation:

- Ceramic rolling elements exhibit a lower coefficient of friction compared to steel. This reduction in friction minimizes heat generation, which is particularly advantageous in high-speed motors where excessive heat can degrade bearing performance and motor efficiency.
- Because hybrid ceramic bearings have a lower coefficient of friction and operate at meaningfully lower temperatures, lubrication life is dramatically extended.
- Ceramic rolling elements exhibit a lower coefficient of friction compared to steel. This reduction in friction minimizes heat generation, which is particularly advantageous in high-speed motors where excessive heat can degrade bearing performance and motor efficiency.

2. Superior Wear Resistance:

- Ceramic materials, such as silicon nitride, are significantly harder than steel. This hardness improves wear resistance, resulting in a longer operational lifespan even under high-load and high-speed conditions.
- Hybrid ceramic bearings, unlike steel bearings, do not suffer spalling.
- Silicon nitride balls are smoother, rounder, and harder than steel balls, contributing to their superior performance and longevity.
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3. Higher Speed Capabilities:

- Due to their lightweight nature, ceramic rolling elements reduce the bearing's overall mass, lowering centrifugal forces during operation. This allows hybrid ceramic bearings to perform reliably at much higher speeds than their steel counterparts.

4. Enhanced Thermal Performance:

- Ceramic materials exhibit low thermal conductivity and expansion. This property minimizes thermal deformation and ensures stable operation in motors subjected to extreme temperature variations.

5. Corrosion Resistance:

- Unlike steel, ceramic rolling elements are highly resistant to corrosion. This makes hybrid ceramic bearings ideal for applications exposed to moisture, chemicals, or corrosive environments.

6. Electrical Insulation Properties:

- Ceramic rolling elements are non-conductive, providing excellent electrical insulation. This prevents electrical arcing, a common issue in electric motors that can damage traditional steel bearings.
- Unlike steel bearings, there is no need for expensive grounding rings.
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Implications of Motors Controlled by Variable Frequency Drives (VFDs):

Since their invention in the 1980s, variable frequency drives (VFDs) have been heavily used in industrial motors to control the frequency and voltage of power supplied to

motors. This is important for several reasons. VFDs help save on electrical costs, improve system efficiency, and reduce the stress on machines, thereby extending their lifespans. Modern VFDs may also come with diagnostic capabilities or features that can enhance motor productivity.

However, VFDs have their downsides as well. Most notably, VFDs are susceptible to **electrical arcing**, which can cause substantial damage to equipment.

Why Does Electrical Arcing Happen?

According to ceramic bearing manufacturer CBR Bearing, “Electrical arcing occurs when the voltage gets too high and causes an ongoing electric discharge, which can damage your equipment and eventually cause it to fail.”

When it comes to bearings, electrical arcing is especially damaging. When the voltage produced exceeds what a traditional steel bearing’s lubrication can absorb, small pieces of the steel balls in the ball bearings can break off, leading to bearing failure. This failure often cascades, causing the machine shaft to fail and ultimately leading to the breakdown of the machine itself. Such failures halt production until repairs can be made, resulting in significant downtime and costs.

How Hybrid Ceramic Bearings Mitigate This Issue:

Hybrid ceramic bearings are uniquely suited to address the challenges posed by VFD-induced electrical arcing:

- The ceramic rolling elements in hybrid bearings are non-conductive, preventing the flow of stray electrical currents through the bearing.
- By eliminating the risk of electrical arcing, hybrid ceramic bearings extend the operational lifespan of motors and reduce the likelihood of costly machine breakdowns.

Comparative Analysis:

Property	Hybrid Ceramic Bearings	Traditional Steel Bearings
Friction Coefficient	Lower	Higher
Wear Resistance	Superior	Moderate
Speed Capabilities	Higher	Limited
Thermal Conductivity	Lower	Higher
Electrical Insulation	Excellent	Poor
Corrosion Resistance	High	Low

Property	Hybrid Ceramic Bearings	Traditional Steel Bearings
Initial Cost	Higher	Lower
Total Cost of Ownership	Lower (longer lifespan, less downtime)	Higher (frequent replacements, repairs)

Applications in Motors:

Hybrid ceramic bearings excel in a variety of motor applications, including:

- 1. Electric Motors:**
 - Reduced friction and heat generation ensure efficiency and reliability in electric vehicle (EV) motors, HVAC systems, and industrial machinery.
 - 2. High-Speed Motors:**
 - Lightweight ceramic elements allow hybrid bearings to handle the extreme speeds required in precision CNC machines, medical devices, and high-speed spindles.
 - 3. Motors in Harsh Environments:**
 - Corrosion resistance and electrical insulation properties make them ideal for motors used in chemical processing, marine applications, and renewable energy systems.
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Challenges and Cost Considerations:

While hybrid ceramic bearings offer numerous advantages, their initial cost is higher than that of traditional steel bearings. However, the reduced maintenance, longer lifespan, and improved performance often offset the upfront investment, making them a cost-effective solution in the long term. Engineers should assess the specific requirements of their motor applications to determine the cost-benefit ratio.

Conclusion:

Hybrid ceramic bearings represent a significant advancement in bearing technology, offering unparalleled benefits over traditional steel bearings in motor applications. Their superior performance in terms of friction reduction, wear resistance, speed capabilities, thermal stability, and electrical insulation positions them as the ideal choice for modern, high-performance motors. Additionally, their ability to mitigate issues like electrical arcing in motors controlled by VFDs further underscores their value in industrial and high-tech applications. Industries seeking to enhance motor efficiency, reliability, and durability should strongly consider integrating hybrid ceramic bearings into their designs.

References:

1. Manufacturer specifications and performance data for hybrid ceramic bearings.
2. Research studies on bearing material properties and their impact on motor efficiency.
3. Case studies highlighting successful implementations of hybrid ceramic bearings in industrial applications.
4. Insights on VFD challenges and solutions from CBR Bearing and industry experts.

For more information or to discuss how hybrid ceramic bearings can benefit your motor applications, please contact Mike Quinn Quinntech Solutions 617-538-8756 Email: quinntech@quinntech.solutions Web: www.quinntechsolutions.com