Basics of the Geometrically Contoured Bearing

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A new bearing design concept, known as the Geometrically Contoured (GC) Bearing, has been developed. The name refers to the design configuration which structurally modifies the contacting wear surfaces in order to reduce wear, operating temperature and other detrimental results of friction. Powdered metal materials (PM) are utilized in their construction, and the balls and rollers normally used by conventional bearings are eliminated. Replacing these components is a contoured surface comprising lands (contact surfaces) and pockets (debris traps).

Comparison of a Geometrically Contoured Bearing with a standard universal joint needle bearing

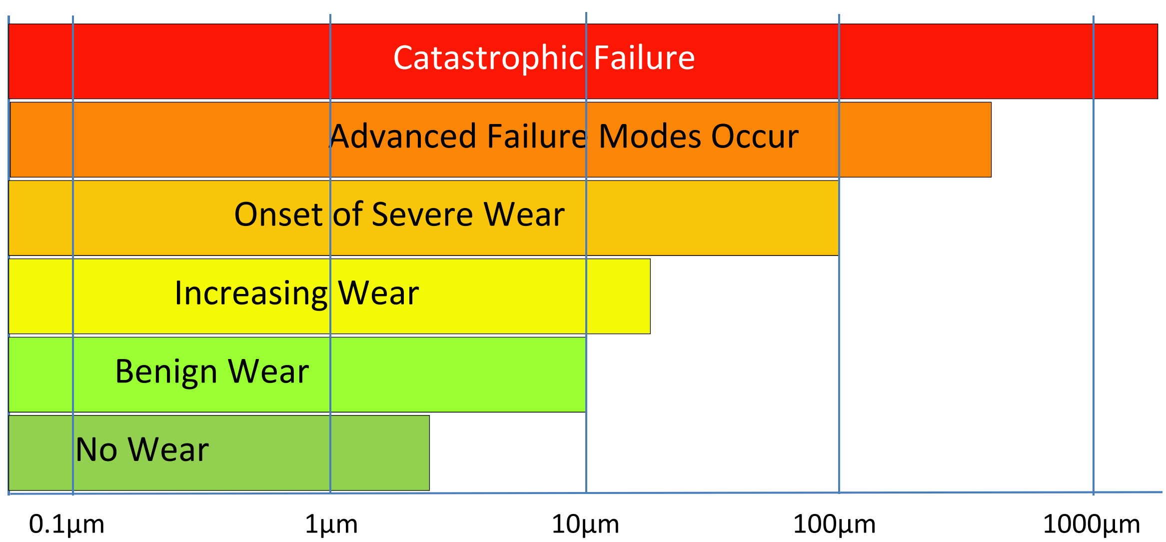
A powdered metal, sliding, bearing with a Geometrically Contoured (modified) surface outperforms normal roller & ball bearings, and also traditional powdered metal sliding bearings in many current applications. This is achieved by addressing the fundamental issues of wear and friction in two ways:

At the macroscopic level, the GC Bearing removes the destructive wear debris that is generated between the contacting surfaces ceasing further surface deterioration and wear. This is accomplished through the geometry of the contoured surface which promotes removal of debris from the working surfaces and provides pockets for the capture and isolation of the wear particles. The GC Bearing is essentially self-cleaning.

At the microscopic level, it prevents the actual generation of these wear particles in the first place. This is done by selecting a PM material with the desired size and shape powders that are compatible with the composition of the lubricant selected. These must promote the proper interaction with the macroscopically determined contour design.

Traditional bearing wear control design methodology is based on the use of wrought metals, which is an alloying of various metallic elements, i.e., a blending of them in their liquid states. This alloying process establishes the alloys' surface composition and topology in addition to the basic structure's mechanical properties. The size and shape of the wear debris generated by the rubbing action of mating surfaces is unpredictable and random. They are generally a result of a surface adhesion and abrasion (i.e., scoring, galling).

Research employing ferrography[1,2] and Atomic Emission Spectrometry[3] has been able to establish a correlation between the operating life of lubricated equipment and the size and shape, and the volume, of the debris found in a sample of its lubricating oil[4]. A large concentration, i.e., volume of wear particles, normally signals replacement of lubricating oil, however, it is not the primary threat[5] to bearing life. The presence of randomly shaped debris with approximate diameters of 15 µm or more, regardless of concentration, is truly the most accurate indicator for the need of immediate attention. A large concentration of these particles indicates that the entire bearing must be replaced, not simply the lubricating oil. The >15 µm sizes additionally promote rapidly the generation of still larger, more disastrous sizes of debris.



Wear Particle Size Spectrum

Debris below 3 µm are not a factor in failure. A large concentration of this size is, in fact, beneficial because it polishes the surfaces rendering the surfaces less susceptible to the generation of larger, failure causing, wear particles. If the volume continues to increase, however, the lubricating oil must be replaced, but, not the entire bearing.

The surface wear behavior process for components made from powdered metal materials (PM) behaves differently. This results directly from the use of powders whose generated debris particles reflect the powders dimensions thus differing greatly from the wrought metal debris. The powdered metal wear debris particles, unlike an alloyed material, are largely predictable.

Most importantly for our bearing design innovation, any impact or rubbing shearing action creates debris that reflects the size and shape of the original powders. The particle size spectrum of powders available for use extends from 0.1 to 1,000 µm. They range from ultra-fine (0.1 to 1 micron) to coarse (100 to 1,000 micron). Thus, fine powders in the beneficial size range (<3 µm) can be chosen. Further, spherical shapes, the least detrimental shape in a bearing rubbing action, can also be selected. Those used in the GC Bearings are in the fine (1-10 micron) range.

Powdered materials are first mixed, which is a non-liquid, non-chemical, blending. The powders are then pressed into the desired component's shape and dimensions (Compaction). Bonding of the powdered elements follows and is done in furnaces (Sintering) at controlled temperatures that do not permit the mixture to reach a liquid state. The elemental bonding process is basically a weld between powders. As the powders bind in sintering, their surfaces also round (smoothen), reducing sharp edges. The resulting mechanical properties and surface topography, even for alloyed materials with identical compositions, can be significantly different. Since powders do not reach a liquid state, metallurgical and chemical combinations are possible that cannot be combined in the liquid, alloying state.

There are additional advantages to the use of powdered metal technology in the manufacture of the GC Bearing. Powdered metal components have a porosity that can be accurately controlled. This porous structure is utilized as a reservoir for replenishment of the base oil used in the lubricating grease. A common failure mode is grease “drying out” as the oil is depleted from the lubricating compound. The GC Bearing reduces or eliminates this failure by “wicking” additional oil to the work surfaces and rejuvenating the lubricating properties of the grease. The GC Bearing structure is impregnated with the base oil during manufacture to provide this self-lubricating property.

The design of the Geometrically Contoured Bearing allows for a higher load capability than traditional rolling element bearings. The work surfaces in the GC Bearing (lands) provide a much larger supporting surface than the point contact of a ball bearing or line contact of a needle element. The increased surface area can conservatively provide a ten-fold increase in the load carrying capability of the bearing.

In summary, the Geometrically Contoured Bearing concept addresses common rolling element bearing failure mechanisms by combining specific materials of construction with innovative structural design. The result is a self-cleaning and self-lubricating bearing structure. This concept has been proven in the high impact, high load environment of drive train universal joints. The innovation offers reduction or elimination of routine maintenance and higher load carrying capabilities along with a simplified installation procedure.

References:

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