Fluid Dynamic Bearing Spindle Motors: Their future in hard disk drives

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Abstract

Hard disk drive (HDD) designs have continued to evolve over time to meet the ever-changing requirements of applications, performance, and cost. Ball Bearing spindle motors have been the common design-in for HDDs for many years; however, the market is shifting toward a different type of bearing design known as Fluid Dynamic Bearings (FDB). This white paper addresses why this change is taking place and the attributes and issues associated with these designs.

Introduction

Areal densities of hard disk drives (HDD) in the past have increased at significant rates of 60 percent to more than 100 percent per year. This trend has slowed more recently to approximately 40 percent per year due to technology challenges. Areal densities today are close to 100 Gb/in2. HDDs are being used more often as digital applications in the consumer electronics industry explodes, requiring much higher capacities and setting new expectation for lower acoustics.

All of the above makes Fluid Dynamic Bearing spindle motors attractive for minimizing Non Repeatable Run-Out (NRRO), lowering acoustical noise, and improving reliability.

Ball Bearing and Fluid Dynamic Bearing motors

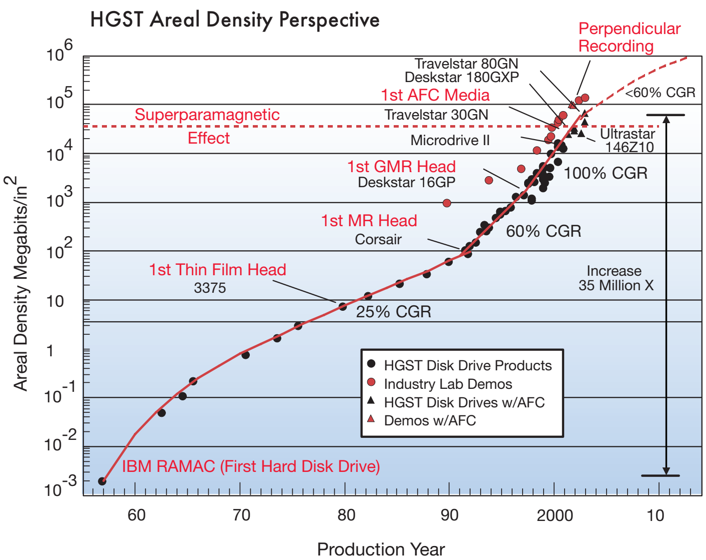
Ball Bearing (BB) spindle motors comprise a significant number of shipments in hard disk drives today. A transition to Fluid Dynamic Bearings (FDB) is occurring in the HDD industry. The trend of incorporating FDB motors in HDD designs is a direct result of higher areal densities and much faster spindle speeds being achieved for today's applications.

NRRO is the highest contributor to Track Mis-Registration (TMR), thus impacting HDD performance. NRRO is also considered an inhibitor in achieving higher track densities. Ball Bearing motors produce larger NRRO due to the mechanical contact with the inherent defects found in the geometry of the race ball interface and the layer of the lubricant film. Ball Bearing spindle motors have minimized this issue with tighter tolerances and closer inspections. There is an upper limit at which the Ball Bearing design can no longer overcome the NRRO problem at the higher areal densities. Currently with Ball Bearings, NRRO has settled in the 0.1 micro-inch range.

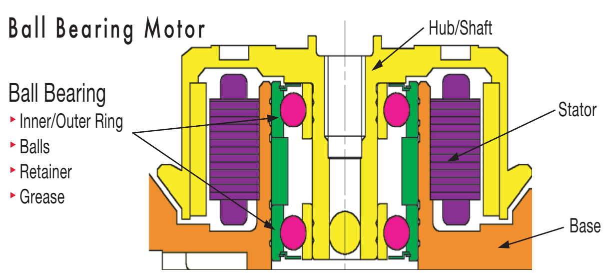
By contrast, FDB generates less NRRO due to the higher viscosity of lubrication oil between the sleeve and stator. FDB designs are expected to limit NRRO in the range of 0.01 micro-inch. Other inherent properties of the FDB design are higher damping, reduced frequency resonance, better non-operational shock resistance, greater speed control, and improved acoustics. Non-operational shock improvement is a result of a much larger area of surface-to-surface contact. Noise levels are reduced to approximately 20 dBA, since there is no contributing noise from Ball Bearings.

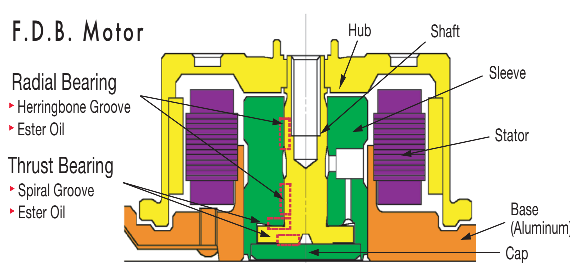
Fluid Dynamic Bearing motors in mobile and desktop hard disk drives

In addition to server class hard drives and desktop hard drives, mobile hard disk drives become prime candidates or FDB motors due to the high areal densities that are being achieved with today's technology. Desktop and mobile HDD track densities today are exceeding 100,000 tracks per inch (100 kTPI), which can



Illustrated below are two drawings depicting a Fluid Dynamic Bearing design and a Ball Bearing design used in mobile hard disk drives.





compound the issues of NRRO. Incorporating FBD motors in the design of desktop and mobile hard drives solves many of the issues of NRRO.

An important metric for mobile hard disk drives is the ability to withstand non-operational shock resistance. FDB motors provide additional shock resistance beyond that of Ball Bearing spindle motors. A contributing factor is the additional surface area inherent in the FDB design. There is more conforming surface contact through the lubricant as compared to the Ball Bearings and raceway surface contact of the Ball Bearing design. Additionally, the lubricant film provides additional damping to shock.

Lower acoustics has become an important focus of system platform manufacturers and manufacturers that are integrating hard disk drives into consumer electronics products.

Fluid Dynamic Bearing motors provide improved acoustics over traditional Ball Bearing spindle motors. The source of acoustic noise in the HDD is the dynamic motion of the disk and spindle motor components. The sound components are generated from the motor magnet, stator, bearings, and disks. These sound components are all transmitted through the spindle motor to the HDD base casting and top cover. Eliminating the bearing noise by use of FDB spindle motors reduces one area of the noise component that contributes to acoustic noise. In addition, the damping effect of the lubricant film further attenuates noise contributed from the spindle motor components. This results in lower acoustic noise from HDDs employing FDB spindle motors. Industry data has shown a 4dBA or more decrease in idle acoustic noise or some HDD designs.

Conclusion

While FDBs are being improved to overcome the issues associated with temperature characteristics related to power consumption, their overall advantage to achieving high areal density, minimized NRRO, and better acoustics makes them attractive for HDD designs. Fluid Dynamic Bearing motors will continue to be used more frequently in hard disk drive designs, particularly in applications requiring very high spindle speeds, high areal densities, and low acoustic noise. Fluid Dynamic Bearing motors will be the standard design-in on future hard disk drives incorporating these advanced technologies.

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