CHEETAH X15-36LP

TECHNOLOGY PAPER

FROM SEAGATE

FDB Motor Technology

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FDB Motor Technology

With the introduction of the Cheetah® X15 36LP and Cheetah 36ES, Seagate® delivers to the enterprise market the industry's most proven FDB motor. Fluid dynamic bearings (FDB) are a substitute for the traditional ball bearing motors used in previous generation drives. This new bearing technology enables high spindle speeds, low acoustic noise emission, and improved shock performance, while ensuring higher reliability at increased track densities. This is achieved by eliminating the metal-to-metal contact found in ball bearings.

The rolling elements in ball bearings produce vibrations due to small imperfections in their geometry. These vibrations produce acoustic noise and are an important factor in drive tracking capability at high track densities. In addition, in ball bearings, shock loads are absorbed by point contacts between the balls and the races, which the balls roll against. Under large load, the races permanently deform, leading to increased acoustic noise and spindle vibration.

In an FDB motor, the bearing function is performed by a thin layer of fluid, thinner than one-tenth the thickness of a human hair. This fluid film separates the rotating and stationary members of the bearing, allowing for vibration-free quite operation. An FDB spindle spreads shock loads over a larger area within the bearing, greatly increasing the shock capability. In addition, the fluid provides mechanical damping, reducing the load amplification due to ringing, a common issue with ball bearings.

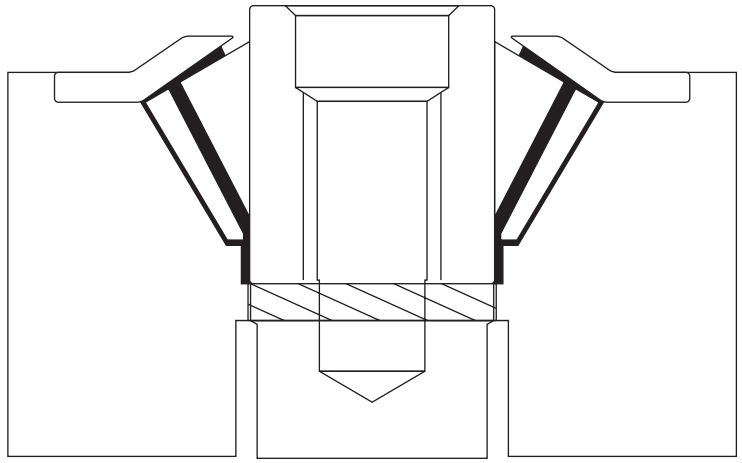

Figure 1. *FDB cross-section. Fluid lubricant shown in black.*

Mature Technology

FDB technology was developed over 50 years ago for use in gyroscopes, high accuracy machine tools, and low noise applications in submarines. This array of applications drove a steady flow of research that resulted in a general understanding of the design techniques and behavior of fluid bearings. Seagate was the first disc drive manufacturer to successfully implement FDB motors, meeting the high reliability requirements of disc drive applications. Seagate has produced these drives with FDB motors in volume since 1997.

High Reliability

Seagate spindle motors are designed for high reliability, accuracy and lifespan. This, in turn, results in a high MTBF rating. Seagate ensures these reliability requirements with appropriate design strategies, aggressive life testing, and long-term reliability testing. On-going reliability testing of these motors has proved an observed MTBF in excess of 4.3 million hours. The life expectancy of Seagate FDB is proven to be as good or better than that of a ball bearing spindle.

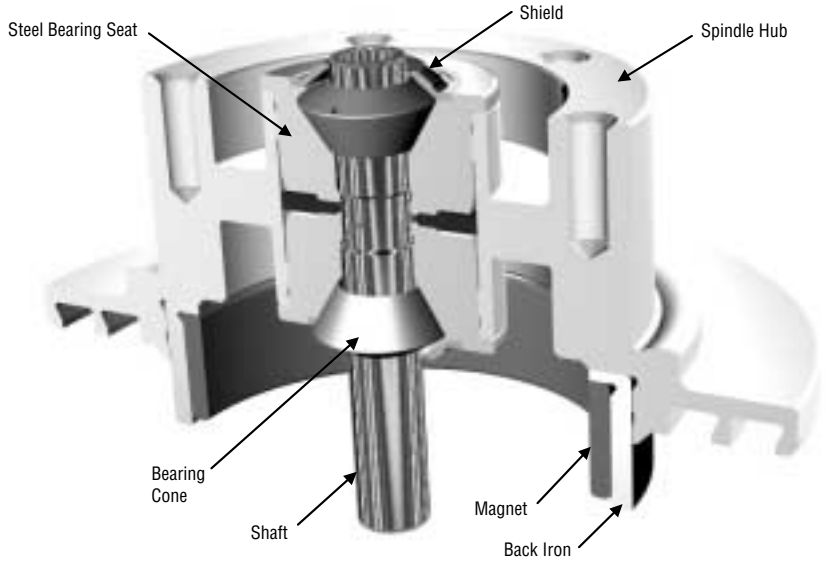

Figure 2. *Cheetah X15 36LP cross-section*

Design Strategies

The robustness of FDB is due to the increased load bearing surface area. Too large a contact surface, however, may create excessive wear during start and stop. Seagate's enterprise motor design ensures that wear resistance is achieved with a proprietary coating technology applied to the bearing surfaces. In addition, the contact mechanics of the bearing are carefully controlled through design of the contacting surfaces. A small crown is machined into each bearing. Through this combination of wear coating and bearing geometry, a design with both high shock capability and wear resistance is achieved.

Life Testing

Life testing uses accelerated test conditions to ensure that rates of wear, evaporation and breakdown meet life expectancy requirements. Under Arrhenius's Law, the speed or rate of chemical reactions and other temperature-driven phenomena doubles with every increase of 8 to 10 degrees Celsius of the ambient temperature. Consequently, a 6-month test under conditions exceeding the specified temperature range by 30 degrees C can verify a life expectancy of 5 years.

The change in weight of spindles in test is used to quantify the amount of lubricant evaporation that is taking place. Multiple control samples, with and without lubricant, spinning and stationary, are used to make accurate weight change measurements on spindle-disk-stack assemblies weighing up to 100 grams.

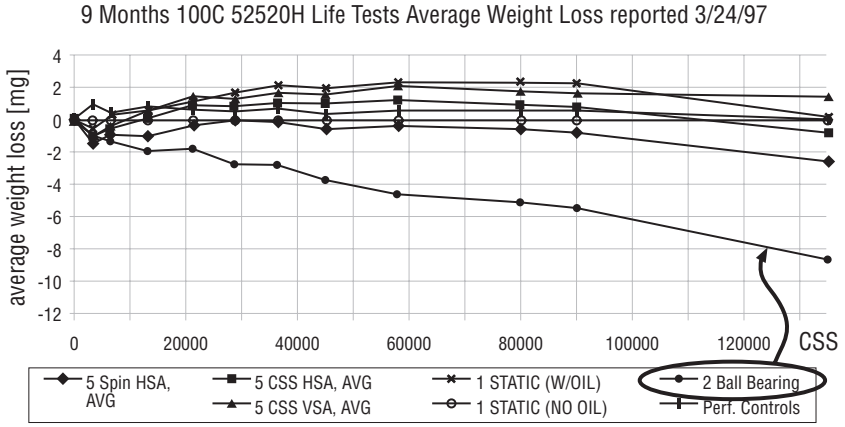

Figure 3. *Life test performance vs. start/stop cycles*

Ensuring longevity of the bearing lubricant is not an issue unique to FDB. Weight change data from an extended 9-month life test is shown in Figure 3. The weight change of the individual FDB spindles remained within a range of +/–2 mg. The larger weight loss experienced by the ball bearing spindles is due to evaporation of the bearing grease base oil.

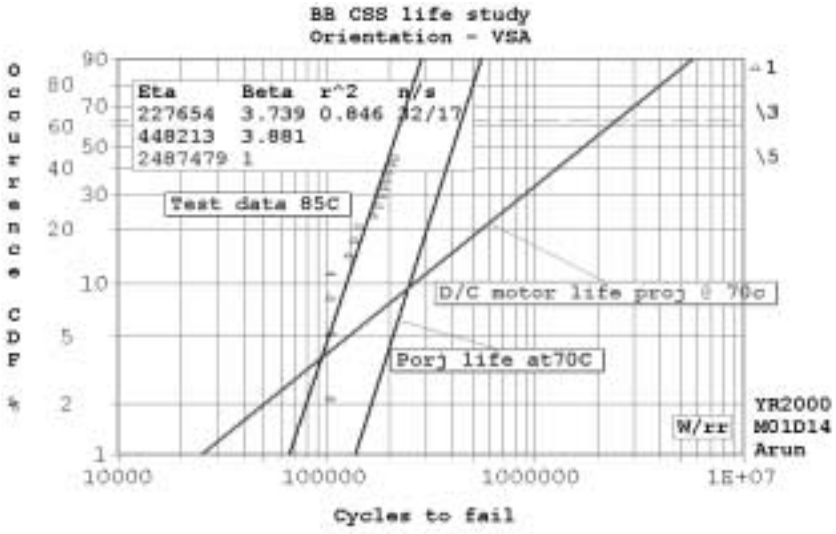

Figure 4. *Wear test performance*

Defect occurrence data from an accelerated wear test is shown in Figure 4. Test data was collected under accelerated conditions at 85 degrees C. The conclusion of the test is drawn from a projection of the test data to a lower temperature of 70 degrees C.

Conclusion

Seagate has once again proven its leadership position in the storage industry with the introduction of FDB spindles into the Cheetah 36ES and Cheetah X15-36LP enterprise-class products. This bearing design combines high reliability with excellent performance. Fluid bearings improve overall drive robustness and enable Seagate's drives to be the quietest in the industry.

Seagate Technology LLC
920 Disc Drive, Scotts Valley, California 95066, USA

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