Boron nanotechnology-based lubricant additive

Test results suggest the technology could replace an antiwear/extreme pressure additive package while increasing performance.

KEY CONCEPTS:

- A new boron nanotechnology incorporates potassium borate nanoparticles dispersed in a fatty acid ester carrier. The technology can be used in oil and water-based fluids.
- The dispersion of potassium borate nanoparticles is unaffected by water, contaminants and changes in pH. Dispersions have remained stable for three to four years.
- Favorable results have been obtained from Falex Pin and Vee Block and Four-Ball wear testing. The boron nanotechnology has performed well in lithium complex grease and engine assembly and break-in lubricant applications.

Growing interest in the use of nanoparticles as lubricant additives has led researchers to work with traditional solid lubricants as boric acid. Micron-sized boric acid has been found to reduce the coefficient of friction to between 0.02 and 0.1 when used on ceramic and metallic surfaces.

As discussed in an earlier article[1], nano-sized boric acid, between 50 nanometers and 100 nanometers, were developed and found to be much more readily dispersible in mineral oil basestocks than micron-sized particles. This performance feature enabled nano-sized boric acid to reduce friction by two-thirds in bench test evaluations of lubricants.

There is need for boron-based nanoparticle technology that can produce robust dispersions that are more stable in the presence of water and other potential contaminants.

It is speculated that the coefficient of friction reduction is due to nano-boric acid crystalline lattices forming surface boundary films that slide easily over one another. Nano-boric acid is compatible with most of the additives used in automotive lubricant formulations.

But nano-boric acid is susceptible to agglomeration when exposed to water. This process leads to an increase in particle size and a reduction in dispersibility in mineral oil basestocks. Surfactants were able to minimize the agglomeration problem but were not able to eliminate the problems encountered with stabilizing the dispersion over a long period of time.

There is need for boron-based nanoparticle technology that can produce robust dispersions that are more stable in the presence of water and other potential contaminants. Such technology has not become available until now.

POTASSIUM BORATE NANOPARTICLES

A new approach has been developed to incorporate boron-containing nanoparticles in an ester matrix that produces an additive exhibiting lubricity, antiwear and extreme pressure characteristics. STLE-member Jim MacNeil, vice president and co-owner of DRD Additives LLC, in Crown Point, Ind., says, "We have developed a product that incorporates boron-based nanoparticles in a naturally occurring fatty acid ester carrier. This ester has a high affinity for adsorbing on the surface of metal and facilitates the movement of the boron nanoparticles to the surface."

‘We found that the nanoparticle dispersion remains unaffected when water is introduced.’

The boron nanoparticles are prepared from potassium borate. When they reach the metal surface, MacNeil explains, the boron nanoparticles chelate to the metal to form a layer that reduces friction and provides extreme pressure performance. He adds, “This film is present to some extent at room temperature, but its formation is accelerated between 93 C and 260 C.” The quality and strength of the film improves as the temperature increases.”

The boron nanoparticle-based lubricant additive is prepared through a proprietary manufacturing process, according to MacNeil. The nanoparticles produced are small and uniform.

The dispersion of potassium borate nanoparticles in the ester does not agglomerate in the presence of water and is not adversely affected by other contaminants. MacNeil says, “We found that the nanoparticle dispersion remains unaffected when water is introduced. In fact, the additive has been used in an emulsifiable MWF fluid containing components such as a sodium sulfonate emulsifier base. Stability has been good, even in the presence of hard water.”

Figure 3 | **One of the applications that shows promise for a new boron nanoparticle-based lubricant additive is in lithium complex greases. In one application, the additive was able to replace the entire antiwear/extreme pressure additive package in the grease leading to an increase in performance.** *(Courtesy of DRD Additives LLC)*

The dispersion is even unaffected under low and high pH conditions. MacNeil revealed that the boron nanoparticle-based lubricant additive was stable, even at a pH of 11. Dispersions of the boron nanoparticles in the ester have even remained stable for three to four years.

Falex Pin and Vee Block testing was conducted to evaluate the boron nanoparticle-based lubricant additive vs. another boron-containing lubricant and a fluid prepared with polytetrafluoroethylene. At a treat rate of 3.5% in 100 neutral base oil, the boron nanoparticle-based lubricant additive achieved a load of 4,000 lbs prior to failure during the Falex Pin and Vee Block Test. This figure is more than three times higher than the other boron-containing lubricant. Coefficient of friction measurements showed that the boron nanoparticle-based lubricant additive exhibited a figure of 0.037, which is almost half the 0.071 value obtained for the other boron-containing lubricant.

The polytetrafluorethylene-based lubricant exhibited a Falex Pin and Vee Block failure load of 2,500 lbs, and a coefficient of friction of 0.054.

Four-ball wear testing was conducted by incorporating the boron nanoparticle-based lubricant additive at a treat rate of 2.5% in a 10W-40 synthetic motor oil that meets the GF-4 specification. In testing vs. a zinc dialklydithiophosphate (ZDDP) additive also used at 2.5%, both additives produced wear scar diameters in the 0.35- to 0.40-mm range, which is much lower than the 0.85-mm figure obtained just for the base oil. MacNeil adds, “We believe that the boron nanoparticle-based lubricant additive achieves a wear reduction comparable to ZDDP without the need to use zinc.”

Applications that are being looked at for the boron nanoparticle-based lubricant additive are crankcase oils, gear oils, greases and metalworking fluids. The additive was evaluated in a lithium complex grease and an engine assembly and break-in lubricant.

In the former application, the boron nanoparticle-based lubricant additive was able to replace the entire antiwear/extreme pressure package in the grease at a treat rate of 3.5%. Four-ball extreme pressure performance increased to a load of 700 kg and the cup temperature measured during the test declined from 95 C to 72 C.

The boron nanoparticle-containing lubricant additive replaced a traditional antiwear additive package in the engine assembly and break-in lubricant at a treat rate of 2%. Improved four-ball performance was realized along with an improvement in color, viscosity and tolerance to water. In addition, no unpleasant odors were detected, and the boron nanoparticle-containing lubricant additive showed some rust inhibition, enabling the formulator to reduce the concentration of the existing corrosion inhibitor.

MacNeil considers the additive to be useful as an alternative for traditional antiwear and extreme pressure additives. He says, “We consider our product to be useful as a chlorinated paraffin replacement that can be used at one-third the treat rate.”

Further information can be obtained by contacting MacNeil at **jim@drdadditives.com**. TLT

REFERENCE

1. Canter, N. (2008), “Friction-Reducing Characteristics of Nano-Boric Acid,” TLT, **64** (2), pp. 10–11.

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