BARRY D. MOSKOWITZ & MICHAEL KLASCO

The Whys And Hows Of Ferrofluids In Loudspeakers

SPEAKER MANUFACTURERS constantly mention their use of ferrofluids in advertising and briefly describe the benefits in their literature. But after 15 years of supplying ferrofluid to the audio industry and with over 100 million speakers treated, few sales floor personnel have more than an inkling of what function ferrofluid really serves in a speaker. So following herewith is a primer for audio sales consultants and others on the effects of magnetic fluids. In it, we will explain what ferrofluids are, why they are used in woofers and tweeters, and, briefly, what recent advancements have been registered in this technology.

WHAT ARE FERROFLUIDS?

Ferrofluids, sub-microscopic magnetic particles suspended in a lubricating oil, were first created in research for NASA. Ferrofluidics Corp. was founded in 1968 with a license from NASA to research the technical and market development of magnetic fluid technology. Magnetic fluid applications include high-performance bearings and seals, such as used in computer hard disk drives and optical scanners. While ferrofluids' use and application may be familiar to computer and speaker engineers, the advantages are not as commonly known to audio people.

HEAT BUILD-UP IN SPEAKERS

The heat sinks in receivers and power amplifiers are a familiar sight, as most amplifiers are 75 percent efficient, with the wasted 25 percent energy resulting in heat. An amplifier that consumes 100 watts will put out about 75 watts of audio power and 25 watts of heat. When the 75 watts of audio are connected to a speaker, almost all of the power results in heat, with only a tiny amount of signal actually being converted to sound. Only the most efficient speakers achieve efficiencies of five percent, with most dome tweeters and woofers performing closer to two percent.

So let's say we have a 10-in. woofer with a 1.5-in.-diameter voice-coil. The speaker is now connected to its amplifier and tested at a one-watt level for impedance and frequency response. Next, the power is cranked up. Even after just a few minutes, when the speaker is retested, the impedance will be at least double—and most likely even higher. The crossover network point will have shifted significantly. Not only have the characteristics of the speaker system's crossover changed, but the woofers' response has changed, typically with a falloff in its upper range. All of these anomalies are caused by voice-coil heating. The heat generated by the amplifier power passing through the voice-coil is partially transferred to the steel top plate of the speaker's magnetic system, and eventually carried throughout the speaker.

Unfortunately, air is not an adequate conductor of this heat and it builds up faster than the air can carry it away from the voice-coil. Changes in impedance are not the only problem with hot voice-coils, as the heat causes the coil to expand, resulting in the likelihood of scraping the top plate—and failure.

Ferrofluid immerses the voice-coil in a thermally conductive fluid and pulls the heat off the coil fast, reducing or eliminating reliability problems and changes in performance that occur due to heat build-up. Ferrofluid stays in the gap due to the strong magnetic field of the gap.

WHICH DRIVERS USE FERROFLUIDS?

Tweeters and midranges are the most commonly known recipients of ferrofluids. If a ferrofluid is too viscous, then the top-end response of the tweeter

Figure 1. Audio engineers run a vast array of speaker tests, free to customers. Damping, heat transfer, impedance and ferrofluid compatibility are checked.

Barry D. Moskowitz is business manager of Ferrofluidics' Technology Division and Michael Klasco is a company consultant. This article originally appeared in Audio/Video International.

could be over-damped. On the other hand, just the right viscosity will damp out resonance in a tweeter, smoothing response and reducing harmonic distortion. Ferrofluidics Corp. offers a free design service for speaker manufacturers to aid in pre-production testing of ferrofluid compatibility with loudspeakers.

ARE THERE OTHER BENEFITS TO FERROFLUIDS?

Manufacturers who use ferrofluids have found that production yields are enhanced and field warranty returns are significantly reduced. During the late 1970s and 1980s it was believed that this was entirely due to "magneto-static force". The ferrofluid, being magnetically responsive, is attracted to the flux field and pushes back when the coil starts to become off center in the gap, thereby acting as a restoring force to maintain concentricity. Reports based on practical experiences of many manufacturers using ferrofluid have revealed dramatic increases in production yields and decreased field returns. This is only partially due to the levitation effect of ferrofluid (magneto-static force), but also due to reduction in voice-coil operating temperature, keeping the voice-coil from expanding and then scraping the top plate. Even the simple lubrication effect of the fluid is partially responsible for the reduced abrasiveness of coil/top plate collisions. There are still other benefits—for instance, ferrofluid deters dirt or particles from entering the gap and even inhibits corrosion of the coil and gap.

RECENT DEVELOPMENTS IN FERROFLUIDS

In pro-audio, high power levels have driven the development of ferrofluids that can function at extremely high temperatures (400 degrees Fahrenheit or more) without evaporating or gumming up. At home and in their cars many enthusiastic music-lovers overdrive their sound systems into overload and hard clipping, which increases the heating of the speaker's voice-coil. This not only stresses the voice-coil, but also, the ferrofluid. To withstand the resulting intense temperatures, Ferrofluidics has introduced its APG 900 series, boasting long-term high-temperature operation.

Many speaker manufacturers have had very positive results with ferrofluids in both tweeters and in midranges, but some wanted a ferrofluid more appropriate for woofers. Low viscosity and high saturation magnetization was asked for, in order to stay in the gap even at large excursions without requiring extensive changes to existing woofer designs. These requirements, in addition to stringent thermal requirements, made for a difficult technical challenge. Ferrofluidics spent thousands of research man-hours to complete development in 1991 of APG027 woofer ferrofluid .

Ferrofluids increase power handling, stabilize sound quality even at high sound levels, smooth frequency response, reduce distortion and improve transient response. The actual manufacturing cost of materials and labor of using ferrofluids is only pennies per speaker.

The only real cost to the speaker manufacturer is what care he expends in careful design by specifying the appropriate selection and application of ferrofluid to a speaker.

To date, over 100 million speakers have benefited from the application of ferrofluids. Among speaker engineers, it is an accepted technique for performance enhancement, and ongoing research is being conducted by Ferrofluidics Corp. to further advance both the performance and its successful application. db

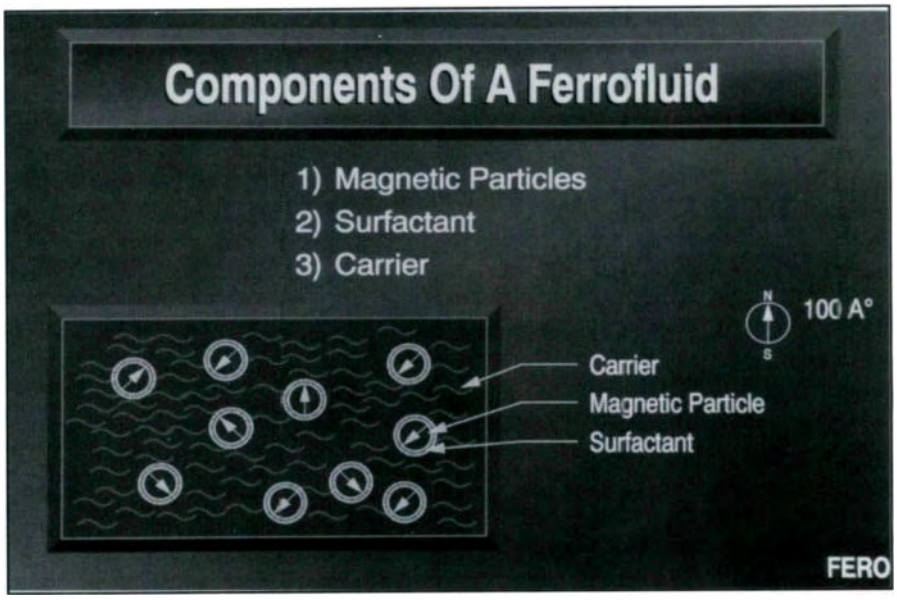

Figure 2. This shows the components of a ferrofluid

Figure 3. The location of ferrofluid in a speaker.