Ferrography: A Noninvasive Method to Inspect Your Gears


Damaged cam bearings.

THE NEAR-DEATH EXPERIENCE OF A CHEVROLET

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In July of 1998 I leased a 1998 Chevrolet, 4 cylinder., 5 speed, Coupe. The car had 33 Kms on it when I took possession. As a part of Munroe Equipment Sciences Inc., I naturally put my car on a Ferrographic Analysis program.

Over a period of a year and a half, I saw my engine deteriorating. From the very first sample, water was a problem and bearing wear was noted. With no "valid" complaint, i.e. noises, excessive fuel consumption, etc., I really had no reason, other than the reports, to have my car looked at. Since this is a relatively new technology, I felt I would be met with considerable resistance if I were to take the car in for service without a physical complaint. Then GM Canada came to us as a customer. I naturally capitalized on the opportunity of having a warranty representative in our office, and told him the story of my car.

Shortly thereafter, I began to smell the fuel my car was leaking. Finally, a "valid" complaint. I called a Chevy dealership out of town because the local dealership I had been dealing with installed the oil filter too tightly, leaving the filter

Would you like to be able to see the condition of the gears in your transmissions without having to open the box and physically examine them? There is a way, and not too many people know about it. It's called Wear Particle Analysis, or ferrography, and it is just starting to get noticed.

Developed in the 1970s by the United States Navy, ferrography is the identification of wear particles suspended in the lubricating fluids of any oil-wetted machinery. It is not a form of used oil analysis, which monitors the state of the lubricant rather than that of the machinery being lubricated. According to Leslie Morovek, the chief administrative officer for Munroe Equipment Sciences Inc. (MES), a Winnipeg-based provider of ferrography services, "Ferrography provides a noninvasive look at not only current and historic conditions, but future conditions of a machine's lubricated components as well." Morovek adds that this is accomplished without the time and expense of a physical examination.

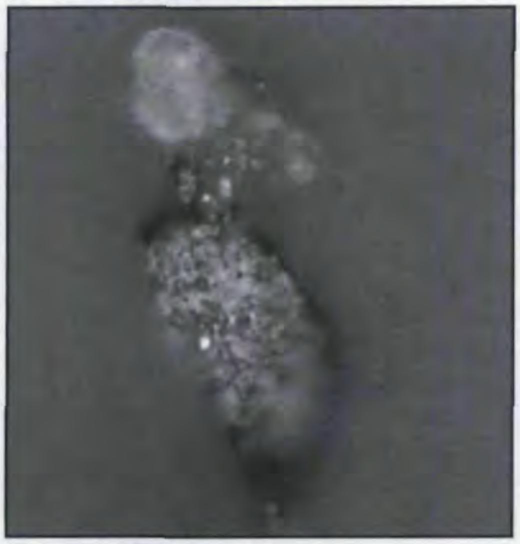
Fig. 1—Normal rubbing wear particle.


Fig. 2—Cutting wear particle.

Theory. Ferrography is based on the theory that once the size, shape, composition and concentration of wear particles has been determined by a trained analyst, these wear particles can then be associated with a specific component within the system. Once that association has been made, the condition of that component can be determined from a careful study of the wear particles.

Practice. According to Morovek, a glass substrate, or ferrogram analysis, is one common way to sort and identify wear particles. One method uses a combination of incline, chemical, thermal or mechanical sample preparation and a magnetic field, ensuring that all particles present in the oil sample are deposited on the substrate. This method also creates consistent ferrogram patterns or maps that provide a repeatable way to sort through the types and sizes of ferrous, nonferrous and contaminant (sand, dirt) particles. "Ferrous particles tend to form strings between the magnetic poles that are perpendicular to the flow of the sample," said Morovek. "The largest particles accumulate near the entry to the substrate and the smallest at the exit. Nonferrous particles often appear between these ferrous strings along with contaminants such as sand, dirt, fibers and friction polymers."

Once the particles have been identified as to composition and concentration, their wear pattern is examined. There are five major types of wear: abrasive, fatigue, corrosion, adhesion and lubricant breakdown. "Cumulatively, the particles in a sample carry with them the story of the internal workings of an individual piece of equipment," said Morovek. "The identification of these particles, and the wear mechanisms that generated them, can effectively demonstrate the equipment's operating history, its current state of performance, as well as generating alarms to future wear conditions."

Wear Particles. Some of the conditions that can be analyzed include normal rubbing wear (Figure 1), which is considered benign unless there are enough particles to affect lubricant quality; cutting wear (Figure 2), which includes a harder surface penetrating a softer surface as well as a softer surface becoming embedded with hard contaminant particles and cutting into a hard surface; and severe sliding wear (Figure 3), which is characterized by particles with sharp, fractured edges and parallel striations on their surfaces.

Gears and bearings have specific types of wear particles associated with them. Bearing wear includes bearing platelet wear particles (Figure 4), which are similar in shape to normal rubbing wear particles but denote abnormal wear patterns; and spheres (Figure 5), which are associated with roller bearing fatigue. According to Morovek, the presence of these dimpled, golf ball-like particles can signal impending wear damage long before spalling and failure actually occur (see "The Near Death Experience of a Cavalier").

Morovek describes gear wear (Figure 6) as a combination of rolling and sliding wear with irregularly shaped particles that have smooth, striated surfaces. "Gear wear is typically very large in comparison to other particles," said Morovek. "The composition of these particles may often be of greater significance than their size, as the progression from high carbon alloy steel to low carbon alloy steels is indicative of the severity of the wear."

The Human Factor

Unlike other methods, which employ a great deal of automation, ferrography still depends on a trained analyst to make the examination and interpret the results. "That is the technology's biggest liability and also its greatest advantage," said Mike Munroe, president of MES. "It's not a science like spectroscopy. Because of the need for a trained analyst, it is more of an art." This makes it slower and more expensive than used oil analysis, but according to Morovek, that time and expense is made-up for by lower maintenance and repair costs and less time spent with machinery off-line for overhaul or component replacement, reducing parts inventory and maximizing productivity for repair personnel.

Fig. 3—Severe sliding wear particle.

Fig. 4—Bearing platelet wear particle.

Fig. 5—Spheres.

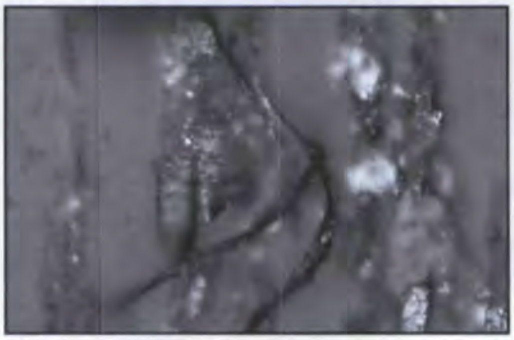

Fig. 6—Gear wear particle.

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media evenly distributed throughout the engine oil. As this happened almost immediately after installation, the next 5000 Kms the engine saw were essentially without an oil filter. This certainly did not help the already abnormal wear patterns.

As the dealership was unfamiliar with us, our technology and our reports (I provided copies), the shop manager contacted GM Canada and spoke with the very same GM official who had earlier been our customer. At this point, it was the opinion of the laboratory that the fuel dilution would cause a severe corrosive condition, furthering the abnormal bearing wear. At this point, the lab did not realize how significantly the presence of fuel had increased the rate of wear. We knew the bearings were in trouble, but didn't think a catastrophic event was at this point imminent.

Based on the analysis we provided, GM Canada gave the "go ahead" to replace the cam bearings. The whole process took about two weeks to complete. Although they were not able to find a direct cause of the fuel leak, all the seals and gaskets were replaced when the bearings were done, and so far, this seems to have fixed the problem.

I will be sampling it again in 2500 Kms to have a better look at the "after repair" condition. The corrosive condition actually "peeled" the surface off the bottom, inside of all five of the cam bearings, leaving the copper underlay exposed.

The long and the short of it is that our lab spotted a problem in the very first sample and GM Canada, without question, made all the necessary repairs. I am no longer driving around wondering if I will get where I'm going.

I'm still not sure which aspect of this experience pleases me more, the incredible level of customer service I received from GM Canada, or the fact that we (the lab) really do have the capability to accurately "predict" the future operating conditions of lubricated equipment.