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Cleveland, OH Walcott, IA

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CENTRAL NEWS©

Issue 829

It Is All About the Film

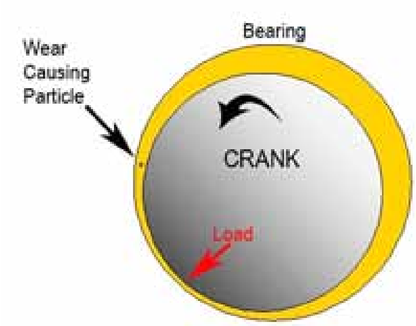
By Blaine Ballentine, Lubrication Engineer

A thicker oil film and more film strength reduces wear. Although everyone agrees with this statement, few understand why it is true.

The following explains the mechanics of wear and how a thicker, stronger oil film reduces wear.

Mechanical Wear

The majority of mechanical wear is caused by tolerance-size particles. The particles can be dirt, wear, rust, or something else. Large particles are caught by screens and filters, and are unable to make it into the gaps to cause damage. The tiniest particles can pass through a gap without touching the surfaces. But if a tolerance-size particle makes it into a gap, something has to give, and it is usually a combination of the particle itself and the surfaces that crush it.



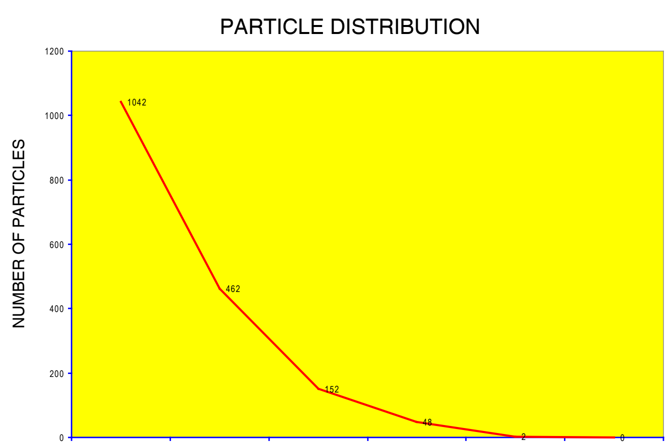
It is fairly easy to visualize this wear mechanism if the particles are between the rings and cylinders or between a crankshaft and bearings in an engine. What is hard to visualize is the size of the particles that cause damage. They are primarily in the 10 to 20 micron size range.

To put it in perspective, a human hair is generally near 80 microns in diameter. If you have good eyes, you may be able to see particles down to the 30 to 40 micron range. Pastry flour or talc can get down into the 10 to 20 micron size range we are concerned with, but we can only see clumps of particles, and not the individual particles.

So now that we know how particles cause wear, it is easy to understand how a thicker oil film can accommodate a larger particle. There are fewer tolerance-size particles causing wear because the tolerance is bigger.

The distribution of particles is also an important factor to consider. Please see the Particle Distribution graph below, which shows the distribution of particles in a sample of new oil. Notice that there are few large particles and a lot of small particles. Particularly notice how steep the curve is between 10 and 20 microns, the size range causing the majority of wear. As the oil film becomes thinner, the parts crunch down on a lot more particles, causing more wear.

Now consider the number of particles shown in Table 1. are in one milliliter of oil, and there are about 30 milliliters in one fluid ounce. We are talking about a lot of particles in a crankcase, and a thicker oil film means fewer particles are crushed, and therefore less wear takes place.



Now we could simply use a thicker viscosity grade, such as a 20W-50 instead of a 15W-40, to obtain a thicker

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oil film. However, it would cause harder starting and probably reduced fuel economy. Therefore, we will compare formulation alternatives that provide a thicker oil film without changing the oil grade.

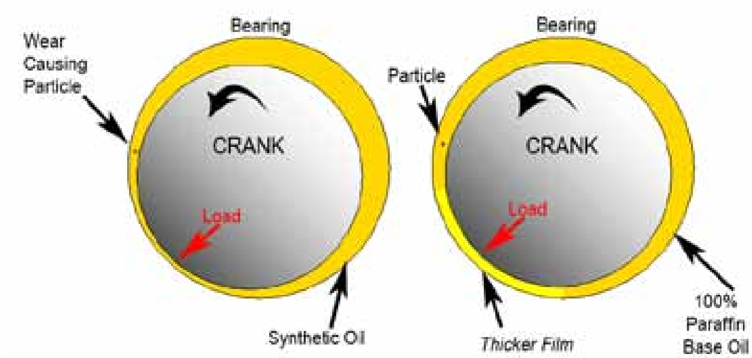
Viscosity Stability

Pressure causes oil to increase in viscosity. The pressures in the high load zone of a heavily loaded bearing can be tremendous—perhaps 10,000 PSI. At that pressure, the oil actually becomes a solid, temporarily, and it is about the consistency of cheese.

The thing is that different types of oil will increase in viscosity at different rates when put under pressure. The proponents of synthetic oils brag that synthetic oils have lower pressure-viscosity coefficients or superior pressure-viscosity stability. In other words, synthetic oils do not thicken up as much when put under pressure.

More pressure-viscosity stability may be desirable for an industrial gearbox under constant loads, but when loads become extreme, mineral oils provide a thicker film that reduces wear.

That is why Cen-Pe-Co uses 100% paraffin base oil in most of its products. When pressures become high, it provides a thicker oil film than synthetic oil and that reduces wear.

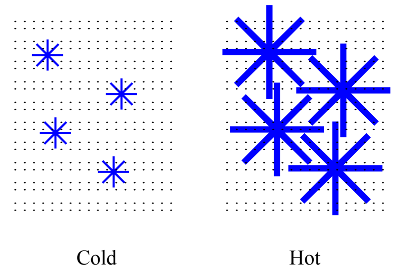


Polymer Shear

Multi-grade oils, such as 15W-40, are made with polymers called Viscosity Index Improvers or just Viscosity Improvers. As the name suggests, polymers are plastics, which are dissolved in oil.

First of all, realize that polymer molecules are huge compared to oil molecules, often 50 to 70 times larger. When cold, the polymer molecules are tightly coiled and have little affect on viscosity. When heated, polymer molecules greatly expand and tangle with each other. As they tangle, they trap the little oil molecules so they can no longer flow freely. This expansion and tangling and trapping of oil molecules is what allows a relatively small amount of polymer to have such a dramatic affect on oil flow and create multi-grade oils.

Just as there are many different types of plastic, there are different types of polymers. Some plastics are harder, stronger, or more pliable than others; and polymers used as viscosity improvers have different characteristics. Since we are interested in film, we will compare how polymers influence viscosity and film thickness.



Polymer shear causes viscosity to drop and the lubricating film to become thinner. There are two types of polymer shear--temporary shear and permanent shear.

Temporary Shear

Temporary shear occurs when an oil loses viscosity while subjected to shear stress, but recovers to its original viscosity when the shear stress is removed. Think an oil losing viscosity as it goes through a bearing, but the viscosity comes back when the oil returns to the oil pan.

Temporary shear is caused by polymer molecules aligning with each other. It is a little bit like forks. If you just throw forks in a drawer they take up a lot more room than if you stack them neatly. Stacking polymer molecules causes viscosity to drop.

When polymer molecules are floating freely, they are tangled and slowing flow. As they are forced through a tight passage or near surfaces in motion, the molecules tend to align with each other and viscosity drops.

You would think this is a bad thing that oil formulators would try to avoid, but that is not the case. The Sequence VID (5D) test for passenger car fuel economy is sensitive to oil viscosity. A polymer that exhibits temporary shear helps defeat the test, so formulators often select polymers based on their ability to shear temporarily.

Temporary shear is determined to a large extent by the size and shape of the polymer molecules. Large linear molecules will shear more than small star-shaped molecules.

Polymers made of large molecules are more efficient than those made of small ones, in that it takes fewer pounds of polymer per gallon of oil to build

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viscosity. However, the large molecules have a greater tendency to align or compress, causing temporary shear.

It generally takes more pounds of polymer made of small molecules to achieve the same viscosity, but they exhibit less temporary shear. Unfortunately, the polymers made of small molecules tend to cost more per pound, and then more pounds are needed to achieve the same viscosity grade.

The shape of the polymer molecules also determines the amount of temporary shear that takes place. Linear molecules, which are most popular, have a tendency to line up and allow viscosity to drop. Star-shaped polymers cannot align well and are much better at holding viscosity under shear stress.

Cen-Pe-Co uses small star-shaped in its engine oils and tractor hydraulic oils to reduce viscosity loss from shear stress. It is one of the ways we build a thicker film to reduce wear.

Permanent Shear

Permanent shear loss occurs when the tearing action of shear stress causes polymer molecules to break. This is how a cheap 10W-40 oil can become a 10W-30 within 200 miles after an oil change. Depending on the polymer, viscosity may drop like a rock early in the drain and then hold, or it may be more of a steady decline throughout the drain interval.

Again, polymer size and shape determines performance. Larger molecules are easier to break than small ones. A long linear polymer is easier to tear apart than a compact star-shaped molecule.

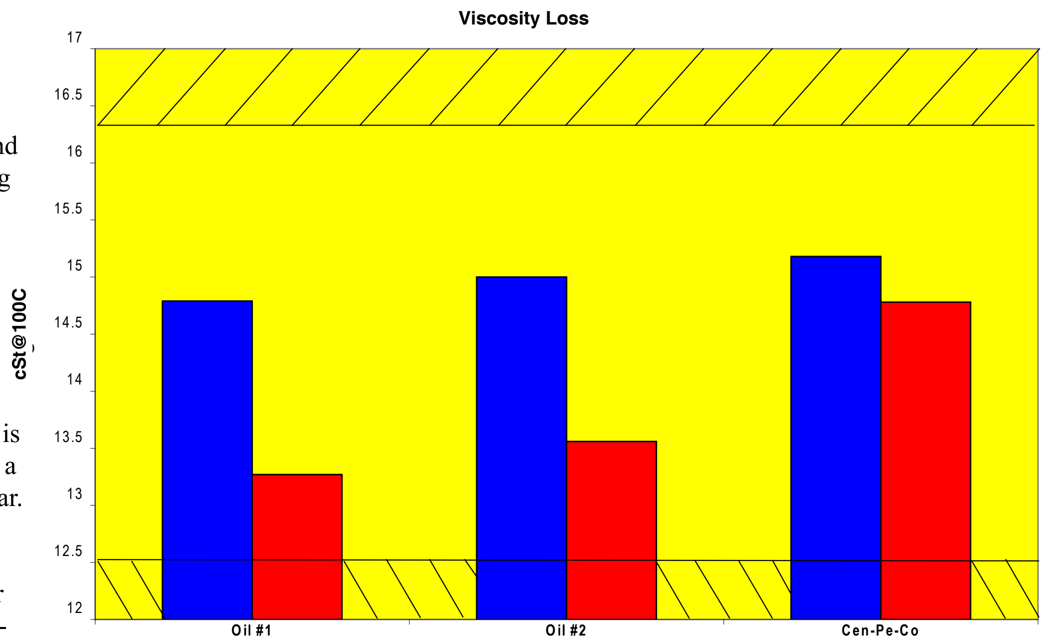
The star-shaped molecules of the polymer Cen-Pe-Co uses make it the most shear stable available. Our engine oils and hydraulic oils are much better at holding their viscosity, and maintaining that thicker oil film than most oils.

The ASTM D7109 is a bench test used to measure permanent shear stability of lubricating oils. Oil viscosity is measured prior to shear stress. The oil is cycled 90 times through a diesel injector nozzle to shear the polymer. Viscosity of the sheared oil is measured, and the amount lost is expressed as a percentage.

Recently, Cen-Pe-Co Extreme Duty SAE 15W-40 was compared with two premium quality nationally available products of the same viscosity grade in the ASTM D7109. While the two national brands lost 10% or more, Cen-Pe-Co Extreme Duty lost only 2.6%.

Summary

A thicker oil film reduces wear. Cen-Pe-Co uses 100% paraffin base oil in most of its products because when pressures become extreme, it will become thicker and reduces wear, even outperforming synthetic base oils.

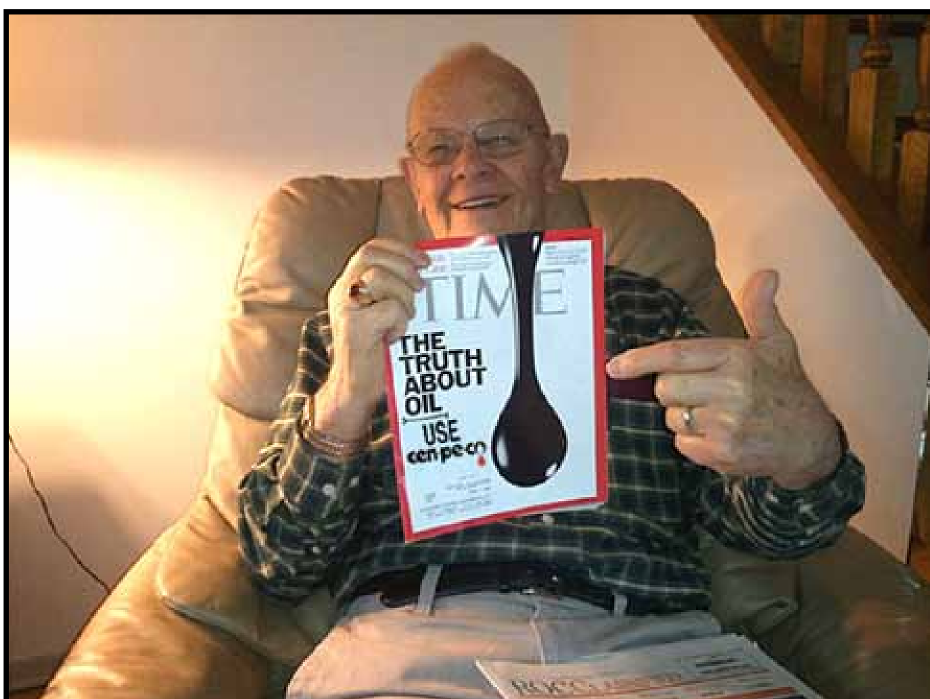


Cen-Pe-Co also uses the most shear stable polymer available in its multi-grade oils. Its star-shaped polymers maintain the oil film when most products' polymers align to allow temporary shear loss. Also, the star-shaped molecules are more resistant to breaking, which causes permanent viscosity loss.

In stopping wear, Cen-Pe-Co provides a superior film.

"The World's Best Heavy-Duty Lubricants"™

Men attending a recent Pennsylvania Sales Meeting (L to R): Wayne Sampson, Herb Rohde, Bob Johnson, Martin Wengerd, Daryl Lehman, David martin, Jonathan Hollinger, Blaine Ballentine, David Spicher, Delton Lehman, Ken Horning, Don Crone, Nelson Lehman, Carl Schmidt, Harry Longnecker, Dave Kauffman, Steve Mosher, Bud Hartman.



Jack Burns (NY) shows off his newest issue of TIME Magazine, "The Truth About Oil"!