

Low-Temperature Performance of Base Oils – Timing Is of the Essence

The low-temperature performance of a finished lubricant is largely determined by the inherent low-temperature properties of the base oil, although performance can be tweaked with additives such as pour point depressants (PPDs) or viscosity modifiers. The major part of the low-temperature performance window is set when the base oil is manufactured.

For paraffinic base oils, with the exception being polyalphaolefins, a dewaxing step is used. However, this does not mean a finished base oil is free of wax or waxy molecules; after all, they determine the pour point.

For crankcase fluids, suppliers generally try to meet the viscometric requirements of SAE-J 300 for cold crank viscosity and low-temperature pumpability. Cold crank and pumpability performance have different responses to the chemical composition of the base oil. Being quite different phenomena, they need different test methods and viscometer types to measure them.

Cold crank viscosity is an indicator of the ability to turn over or crank the engine, and is measured after quite rapid (minutes) cooling of the lubricant. Because wax crystallization from the base oil is strongly dependent on time and viscosity, cold crank measurements allow no time for wax crystals to precipitate and agglomerate into



structures. Hence, high viscosity index base oils have good cold crank performance. Although they may have waxy characteristics, there is no time for wax structures to form and increase viscosity. The VI of the base oil will provide a reasonable handle on cold crank performance, but indicates virtually nothing about pumpability performance.

Pumpability, the ability of a lubricant to find its way to the oil pump inlet, is controlled by any soft/solid structure. This property is measured as high viscosity or yield stress from precipitated residual waxes that may have aggregated after a lubricant is left in a cold environment for a long period.

Molecules with waxy characteristics have inherently high VI. This leads to the paradox that high or even very high VI base oils, especially if solvent dewaxed, can have limited pumpability performance. Perhaps the main

exception to this paradox is found with PAOs, which do not have residual waxes as such because of their unique synthesis and structural characteristics.

The concept that wax crystallization is both viscosity and time dependent is important when it comes to developing and understanding industry standard tests for lubricants.

Therefore, slow cooling times are specified in test methods where it is important to know about time dependency of residual wax crystallization and thickening of lubricants. These tests probe a lubricant's ability to remain homogenous and maintain a low viscosity when left in cold environments for extended times. Examples are the Brookfield viscosity test for automatic transmission fluids that specifies a cooling time of about 16 hours and the mini rotary viscosity pumpabil-

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ity test with a cooling time of about 48 hours, which is part of the SAE J-300 crankcase fluid requirements.

Pour point is a low-temperature parameter that is often quoted, easy to measure and useful for determining whether a base oil is likely to solidify. It is not, however, part of SAE J-300.

Pour point in lubricants can be

modified by judicious use of a PPD. The first order response of base oil to PPD is determined by whether the oil is catalytically or solvent dewaxed. Catalytically dewaxed base oils usually have far better response to PPDs than solvent dewaxed base oils. This is mainly because most residual waxes in catalytically dewaxed oils undergo some degree of isomerization

or cracking.

In solvent dewaxed base oils, the residual waxes – those precipitating at the natural pour point – have the same unimproved wax characteristics as the crude from which they were derived. As a result, solvent dewaxed oils generally respond in a poorer manner to PPDs, which sometimes can be offset with higher dosing.

Because the process of wax crystal formation is strongly viscosity and time dependent, some highly viscous base oils such as bright stocks when cooled become too viscous too quickly for wax crystals to initiate and grow. Therefore, as temperature is lowered, bright stocks reach an ultrahigh viscosity that a pour point apparatus interprets as a pour point. However, it is not because no wax assemblies have formed and is called a viscosity pour point.

Wax eventually crystallizes out as temperature drops because the base oil solution becomes so saturated with residual wax, becomes cloudy and forms wax assemblies. In this special case, cloud point and pour point are inverted compared to conventional distillate base oil behavior where cloud point is normally above the pour point.

So the low-temperature performance of base oil is not simply a matter of "High VI is best." Rather, it's all in the timing! □



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