Lubrication of trucks

I have been investigating a diesel engine failure that occurred because of lubrication starvation at the camshaft bearings. I learned a lot about oil and I want to share some of this with you.

Engine oil is formulated for specific operating conditions and diesel lubricating oil is not petrol-engine oil. The operating conditions the oil experiences is different in these engine types and a different oil 'formula' is needed. Furthermore, diesel oil will be naturally consumed at a higher rate than in a petrol engine.

The task of the oil is to get between rubbing surfaces and minimise wear. Oil circulation through the engine also takes heat back to the sump so it has an important cooling function, particularly in the pistons and the turbocharger.

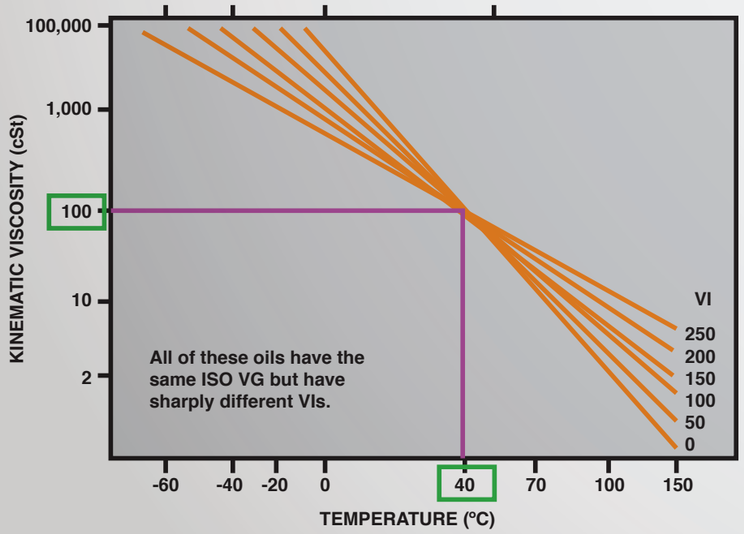
The additives in oil make up a significant proportion of the oil – up to 25 per cent. They may be up to 12 additives in diesel oil. The additives, which are liquid, perform specific functions which are:

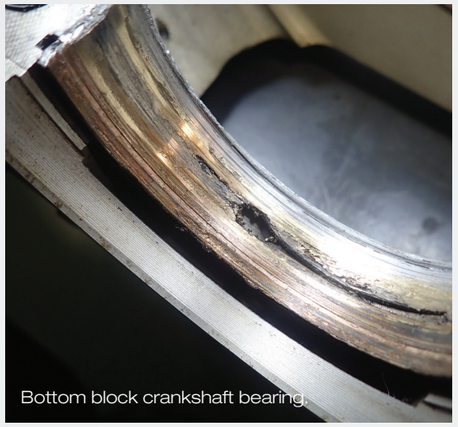
- Detergents to wash away residues.
- Dispersants to keep undesirable impurities in suspension so they don't deposit.
- Anti-wear additives to promote the development of a film on moving parts.
- Anti-corrosion and rust inhibitors to protect metal parts from sulphur that comes in via the fuel.
- Anti-oxidants to minimize oxidation of the oil that could cause increase in viscosity, oil breakdown and formation of sludge and sediment.
- Viscosity improvement to ensure that the oil is not too thick in cold weather and not too thin at maximum operating temperature.

Oil viscosity is tested against commonly used SAE standards to grade it. The higher the viscosity number, the thicker the oil and the more it resists flow.

If viscosity is too great, under cold conditions the moving parts may not get an adequate oil flow. The viscosity of all oils decreases as the oil heats up.

There are 11 SAE viscosity grades which are 0W, 5W, 10W, 20W, 25W, 30, 40, 50 and 60. North American winter grades are given a W designation. The grades are not viscosity numbers. The actual viscosity values associated with a grade can be found in SAE Standard J300 Engine Oil Viscosity Classification.




Bottom block crankshaft bearing.

Winter grade viscosity testing is done at low temperature whereas, viscosity measurements for the higher indices are done at 100oC and 105oC. The variation of oil viscosity with operating temperature can be controlled to some extent by additives. Oil with a high 'viscosity index VI' have less variation of viscosity with temperature. Viscosity index is defined in ISO standard 3448.

Both SAE grade and Viscosity Index are important. A common Australian multi-grade specification is 15W40 with a viscosity index VI=138.

Apart for the SAE grade and the ISO VI grade, you may encounter the American Petroleum Institute API oil grading. API CF4 is a common heavy diesel engine oil grading. Recently grade FA-4 was introduced to classify low-viscosity yet stable oils that might reduce engine friction and improve fuel economy.

The European ACEA rating also exists. ACEA E9 (heavy duty and stable engine oil is suitable for current Euro V and VI engines).

Engine oil returning to the sump of a diesel engine can be 125oC. Engine oil will take in moisture from air and it is important to get the oil to working temperature regularly to evaporate out the water. To do this the oil needs to reach ~100oC.

Oil can be mineral, semi-synthetic or fully synthetic. 'Synthetic' oil can withstand higher operating temperature without deteriorating when compared to mineral oil.

Synthetic oil is usually derived from mineral oil. It is refined and modified to favour hardy lubricating organic chemicals. Oil change intervals can be longer for synthetic oil and mineral oil because synthetic oil has a slower deterioration rate with engine use.

Similar considerations apply to transmission and gearbox oils.

Oil is consumed in an engine. The oil film in the combustion chamber experiences high temperature and will vaporise, burn and be taken out in the exhaust. Diesel engines consume more oil than petrol engines because of the high combustion temperatures and pressures. For an engine that is being properly lubricated, oil consumption of 0.25 per cent (0.0025 x the fuel usage) can be assumed. So for every 500l fill, a top up of 1.25l of oil is required.

Engines that operate on Compressed Natural Gas or have 'LPG to-up' will burn hotter and consume more engine oil. Additives may affect the catalyst performance in a Diesel Particular Filter (DPF) as some of the additives go out with the exhaust.

Oil pressure is another crucial factor. Oil pressure is measured near the outlet of the oil pump. It is a measure of the backpressure in the lubrication system. The factors that can cause abnormal oil pressure are:

- Low oil level in the sump so oil is not being reliably sucked into the pump.
- Contamination of the oil by diesel fuel. This lowers the oil viscosity and can result in low pressure.
- Contamination of the oil by coolant. Water will cause emulsion and oil sludging. Glycol will cause coagulation of the oil also and produce acids that will attack metals. Glycol contamination of oil is public engine enemy No 1!
- The oil filter is clogged. This causes restricted flow.
- Oil lines or passages are not working / clogged.
- Engine oil bypass valve at the oil cooler is stuck open so the oil is not hot enough.
- Oil pick-up restriction. This occurs when the filter screen on the pick-up pipe is clogged. The pump is oil starved and will cavitate.
- Oil pump mechanical problems and air leakage into the pump will reduce oil flow.
- Worn camshaft bearings do not provide restriction against oil flow and the oil pressure is low.

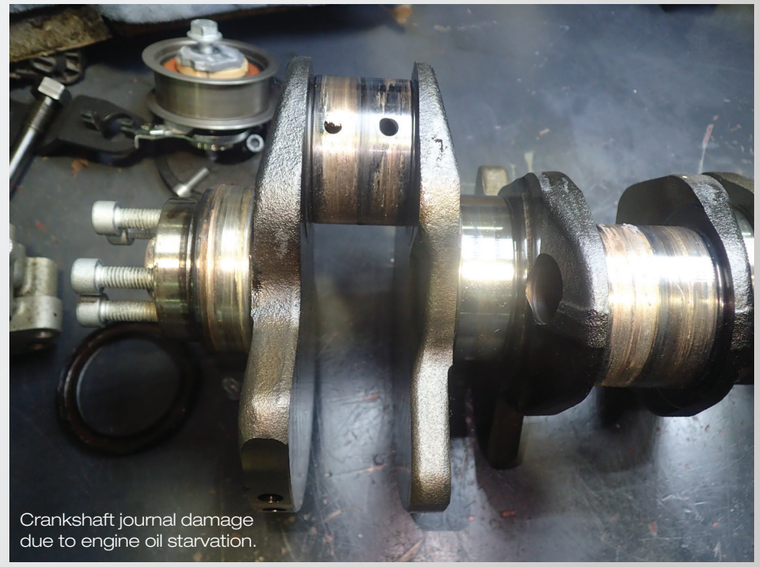
Oil for use in gearboxes and differential axles is different again. Very high oil pressures occur between meshing gears and the oil must not be squeezed away from the contact path. Viscosity is important as is the stability of the oil under shock loading and high temperature.

Additives in oil minimise oil molecule breakdown. Many of the additives that are in engine oils are unnecessary because there are no combustion products in the gearbox. Hypoid oil is used in differential axle bowls because it has additives that make it suitable for the extreme pressure operation that occurs between meshing hypoid gears. Oils for wheel bearings should have high viscosity so it 'sticks' to the slowing rotating parts.

Gear oil classifications are published by the API. These classifications range from GL-1 (manual gearbox with no friction modification) to GL-5 (manual gearboxes with extreme shock protection and anti-wear properties). Usually gearbox oil is specified to be mono-grade such as SAE 50.

As they say, "Oils ain't oils".

Dr Peter Hart,
ARTSA


Crankshaft journal damage due to engine oil starvation.