Synthetic Fluids

“Synthetic” is an all-encompassing term used to describe man made base fluids utilized in the formulation of lubricants. Synthetics can have sharply different performance attributes and can at times be mutually incompatible. The differences between these base fluids must be understood in order to accommodate the needs of the machine application as well as the properties of the lubricant.

What Makes a Synthetic?

Synthetic lubricants do not originate from crude oil like conventional mineral oil. Instead, synthetic lubricants are formulated from derivates of natural gas and other base materials. For instance, polyalphaolefins (PAOs), which are among the most common synthetic base oils, are formulated from ethylene and decene (largely derived from natural gas). Through the process of polymerization, these molecules are built from the ground up and offer a number of benefits. Unlike mineral oils, in which a single batch of oil may contain millions of different molecular structures, the molecular sizes and shapes within a single synthetic oil are much more consistent. This leads to more consistent fluid properties and predictable life cycles.

Synthetic Benefits

Perhaps the most common advantage associated with synthetic fluids is that they last longer in service. This is due in large part to the consistency of their molecules and the lack of aromatic structures. These molecules are much more robust and better able to handle the rigors of operation without oxidizing or thermally degrading rapidly.

Another benefit is the increased viscosity index. Viscosity index is the relationship between a change in viscosity and a change in temperature. The higher the viscosity index, the smaller the relative change in viscosity with temperature. This allows for a single fluid to maintain its viscosity at all in-service temperatures without having to change viscosity grades between seasons. Synthetics also have improved low-temperature performance characterized by a low pour point.

Fire resistance is a common requirement for most turbine hydraulic systems. The majority of these systems use a synthetic fluid to achieve this fire resistance. One of the properties that helps with a fluid’s fire resistance is its flash point, which is the temperature at which a flame propagates across the surface of the oil. Synthetics generally have higher flash points than their mineral oil equivalents.

Synthetic lubricants not only have high-performance basestock but usually also benefit from premium additive systems. In fact, many of the benefits that are commonly attributed to synthetic lubricants actually come from the additives with which they are formulated.

Synthetic Drawbacks

The biggest drawback to using synthetic base oils is the additional cost associated with them. They may be anywhere from three to 15 times more expensive than mineral oil. If you are considering making a switch from mineral to synthetic oils, you must be sure that the benefits to be realized will make up for the additional front-end cost. There are several ways in which this cost can be recouped, such as extending oil change intervals, employing product consolidation or decreasing machine failures.

Another risk with synthetic fluids is the compatibility issues that come with using these lubricants. Some synthetics have been known to cause seals to swell and reduce lubricant flow, while others can dissolve seal materials, allowing leaks and possibly severely damaging the machine.

Not only do some synthetics have compatibility issues with seals, but most have compatibility issues with other fluids. Polyalkylene glycol (PAG) base oils are notorious for their incompatibility with mineral oils, although oil-soluble PAGs (usually called OSPs) largely remedy this drawback. In the event that mineral oils and PAG oils form an incompatible mix, the result is a gelatinous mass that clogs lines and can lead to lubricant starvation and ultimately machine failure. Other incompatibilities for synthetics include paints, hose materials and some additives.

Synthetic esters such as phosphate esters, polyol esters and di-esters are also at risk for hydrolysis. Hydrolysis is a water-induced chemical reaction that can cause a rise in acid number, loss of viscosity and an increase in varnish potential.

Synthetic Types

Polyalphaolefins have been identified as the most common synthetic base oils. They are used in nearly every type of equipment with the exception of compressors that have high discharge pressures, where they have been known to leave deposits. PAOs are miscible with mineral oils and have good demulsibility characteristics.

Polyalkylene glycol oils are used in some refrigeration compressor systems as well as brake fluids, worm gear oils and gas turbine oils. They are unique in that they don’t form deposits as the oil breaks down. PAGs also have a natural detergency and clean up varnish left behind by other fluids. If the base fluid is made by the polymerization of ethylene oxide, the resulting fluid is water soluble and is often used in water-emulsion hydraulic fluids.

Di-esters are frequently used in compressor applications and are often paired with PAOs to help with additive solubility. Di-esters also tend to be hygroscopic in nature, which means they absorb moisture readily. They have a high viscosity index as well as a low pour point, so these oils will remain fluid at low temperatures.

Silicone base oils have the highest viscosity indexes and some of the highest levels of thermal and oxidative stability. These bases are used primarily in high heat applications and some brake fluids. They are typically very costly. In addition, the oxidation byproducts are abrasive and can lead to added machine wear. Silicones are also chemically inert, which makes it difficult to blend additives into them and still have them remain in solution.

Overall, synthetic oils can be tremendous assets to any lubrication program, but they must be matched to the machinery's needs to get the optimum benefit from them. When making the transition from mineral base fluids to a synthetic base, be sure to flush the system to minimize any residual compatibility issues that may remain. By understanding the strengths and weaknesses of the synthetic base you are using, you will be well on your way to achieving all of the advantages associated with these fluids.

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