Turbine Lubricant Maintenance for Varnish Free Operation

Modern gas and steam turbine lubricants require careful maintenance to operate at peak performance. Peter Dufresne of EPT, a world leader in critical lubrication management, reveals the importance of detecting lubricant varnish and how maintenance practices can be updated to prevent varnish related turbine "trips" and fail-to-start conditions.

Gas and Steam Turbine Lubricants

Gas and Steam turbine lubricants consist primarily of mineral oil base stock (approximately 98%) and rust and oxidation additives (approximately 2%). Modern gas and steam turbine lubricants are manufactured from Group II - IV base stocks, which are produced from hydro-cracking or synthetic processes. In contrast, traditional solvent refining techniques produce Group I base stocks. Hydro-cracked and synthetically produced base stocks have limited heteronuclear molecules, less aromatic compounds, improved viscosity indexes and, most importantly, greater oxidative stability than Group I base stocks. While these improvements in purity are a net benefit to the lubricant, it is not generally understood that these improvements change the overall chemistry of the lubricant, which has important implications in lubricant testing and maintenance.

Oxidation, Varnish Formation and Testing.

Oxidation by definition is the loss of an electron. It also normally involves the creation of a deleterious free radical. Oxidation reactions, which constantly create soluble oxidation by-products, are unavoidable in turbine fluids. These oxidation by-products will be dissolved in the lubricant until the saturation point (solvency) for these molecules is exceeded. Once exceeded, the excess contamination will fall out of solution, forming varnish deposits on metal surfaces (bearings, servo valves, and other mechanical components). This process often occurs during a turbine shut down as this is when the oil is cool and cooler temperatures reduce the lubricant solvency.

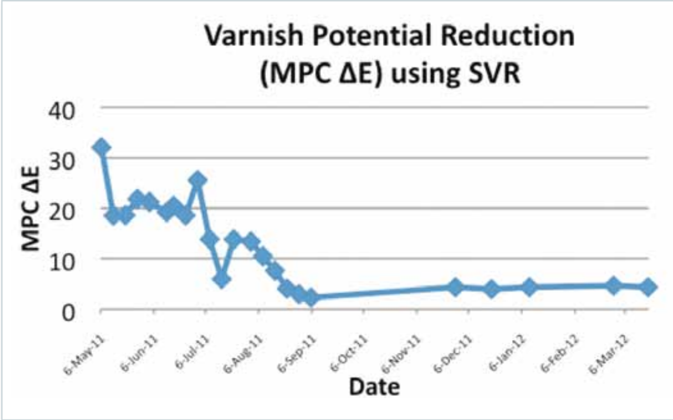
All turbine lubricants will produce soluble oxidation by-products; therefore, it is important to assess the level of their accumulation. Quantitative Spectrographic Analysis (QSA®) and Membrane Patch Colorimetry (MPC – ASTM D02.C01 WK13070) are used to determine the propensity of the fluid to create varnish deposits. QSA™ or MPC testing should always be included with regular turbine lubricant testing. These tests involve mixing a non-polar solvent (e.g. petroleum ether) with an oil sample and then subsequently filtrating the mixture through a 0.45 micron, 47 mm, nitro-cellulose filter membrane. The resulting patch color is associated with a number scale that is used to indicate varnish potential. While the scale of these two methods differ slightly, if a high color value is indicated with either method, it always means the fluid has a high level of accumulated oxidation by-products, hence, a higher likelihood of deposit creation. In other terms, both methods measure the solvency ability of the lubricant; a high solvency indicates a high capacity to hold oxidation by-products in solution and an extremely low potential to form varnish deposits. Operating a turbine lubricant with high solvency properties (and high oxidation stability) should be the goal of all lubricant maintenance programs.

How Improved Oil Chemistry Impacts Fluid Maintenance

As mentioned previously, modern gas turbine lubricants are made from highly refined base stocks that have almost all "impurities" removed. The removal of these impurities has changed the polarity of the lubricant from one previously comprised of polar species to one that is now primary comprised of non-polar species, i.e. more homogeneous. In simplified terms, the "impurities" that previously existed in turbine lubricants (group I) had similar polarity to the breakdown products, which helped keep degradation products dissolved in the lubricant, but reduced oxidative stability and RBOT. This is no longer the case and explains why modern turbine lubricants have reduced solvency or capacity to hold oxidized components. For this reason, a strong case can be made for adding secondary fluid maintenance equipment to remove the breakdown products, prevent accumulation, and maintain high lubricant solvency.

Another change that occurred with highly refined base stocks is improved resistive properties. While this is generally viewed as a positive, it can make it more difficult for static energy to dissipate within a reservoir. In some situations, depending on oil temperature and flow, filter elements can create static energy, which accumulates and then suddenly dissipates in the form of a spark creating temperatures in excess of 1000 °C. These high temperatures cause a severe form of lubricant breakdown referred to as "thermal degradation". Thermal degradation destroys the lubricant molecule and produces more radicals that will significantly accelerate additive

Photos: **Southern Company's Stanton Energy Center, Unit A uses EPT's Soluble Varnish Removal (SVR) System**



consumption. For this reason, steps to reduce thermal degradation should be taken. The best counter-measure against static charge accumulation is the use of specialized, No Spark Discharge (NSD™) filters. These NSD filters are designed to reduce friction, which prevents static energy accumulation.

The Reason Historical Maintenance Practices for Varnish Removal Fail.

Electrostatic oil cleaners (EOC's), agglomeration systems, and depth-filtration systems are all forms of insoluble particulate removal devices. These particulate removal devices have been widely used in the past for varnish prevention, but have fallen out of favor in recent years because of the difficulties encountered while trying to maintain low varnish potential values. These devices are valid methodologies to remove insoluble contamination; however, their usage on an operational turbine is a misapplication. This is due to pre-varnish contamination being dissolved in the lubricant rather than being in the insoluble form during normal turbine operating temperatures. Thus, particulate removal devices will not directly address the issue or cause of varnish. Any particulate removal device used in varnish removal attempts will have to wait for the lubricant to become oversaturated and for by-products to become insoluble. By the time oversaturation has occurred and insoluble by-products have begun to form, the risk to the turbine already exists. Using particulate removal devices after soluble contamination has become insoluble significantly reduces the effectiveness of the overall fluid maintenance program and creates an unnecessary risk to the turbine and the associated production stream.

A Clearer Path Forward: Using Technology to Remove Varnish in its Native form.

SVR™ is a varnish removal and prevention technology that removes dissolved oil breakdown products at normal turbine operating temperature and eliminates the historical accumulation of the oxidation break-down products. By removing these dissolved molecules, the lubricant solvency is restored and the lubricant will return to having a high capacity to hold contamination. Furthermore, pre-existing varnish deposits will be dissolved back into the clean oil and then removed as solvency continues to be improved. The varnish removal process follows the same chemical equilibrium principle from which it was originally created. When you change one side of the equilibrium equation, in this case reducing the level of dissolved contamination, you force a corresponding reduction in the other side of the equation, in this case, solid varnish deposits. SVR breaks the varnish formation cycle as it directly addresses the cause of varnish formation. Moreover, SVR removes the contamination from which ALL varnish is created.

The example above "Varnish Potential Reduction" reports the trend in varnish potential number for several months using SVR technology. The SVR was installed on a gas turbine operating a common lubricant type. As it can be seen, varnish potential values are reduced sharply as the dissolved oxidation by-products are removed. Once the solvency of the lubricant has been restored, an increase in varnish potential value is observed. This secondary increase is normal and explainable – the varnish deposits from within the system are being dissolved back into the clean oil due to its improved solvency which has temporarily increased the concentration of dissolved breakdown products in the lubricant. The duration of this clean-up phase depends on the amount of varnish deposits in the system and, unfortunately, the extent of system deposits cannot be measured by any currently known lab analysis. This clean-up phase lasts between 3-6 months (as shown by the multitude of current and past installations) and is followed by a stability phase that is associated with consistently low varnish potential values. In this example, the clean-up phase lasted 4 months with the varnish potential improving and deteriorating, but following a general downward trend. After the 4 month clean-up phase, this system enters the stability phase where varnish potential numbers are consistently maintained below a ΔE value of 10.

Summary

Modern turbine lubricants are highly purified fluids that have limited capacity to hold oil oxidation breakdown products in solution. Current and future turbine lubricant maintenance programs must address this key point. Since lubricant varnish is created when dissolved oil break-down products are allowed to accumulate beyond the lubricants saturation point, lubricant maintenance systems must be able to remove these dissolved contaminants and prevent accumulation. Particulate removal devices are not effective in this regard as they cannot prevent the accumulation of dissolved oil breakdown products. In addition, because of the improved resistivity in Group II - IV base stock lubricants, NSD filter elements should be considered as part of an effective strategy to prevent thermal degradation and to further protect lubricant additive packages.

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