

Formulating Low Varnish Turbine Technology –

lubricant additives with improved deposit control

Varnish and related deposits occur in a range of lubricant applications where the oil is exposed to high temperatures. It can give rise to a number of issues such as accelerated bearing wear, sticking and faulty operation of control valves, blockage of oil filters and impeded heat transfer. In an operational gas or steam turbine, under such circumstances, control systems will shut down a turbine to prevent any permanent and potentially hazardous damage, resulting in what is often termed a 'unit trip'. A non-operational turbine suffering these issues may not be able to be brought online. The unscheduled downtime arising from these unit trips and failed starts can be extremely costly for an end user. For example, an energy utility company which fails to provide electrical power on an agreed day is contractually obliged to make up the deficit by purchasing power from the market often at highly inflated rates. Costs in excess of \$1 million for a single unit trip are common. Moreover, varnish-related failures are most prevalent for peaking and cycling units, which are brought online intermittently to provide power when grid demand is at the highest. Inability to provide power when most needed therefore has consequences not only for the utility company but for the entire grid.

Several factors have been identified as contributing to varnish formation in turbines. Perhaps the prime reason is the thermal degradation and oxidation of oils by the heat emanating from the superheated steam in a steam turbine or the combustion gases in a gas turbine. Degradation can also occur by the adiabatic compression of entrained air bubbles in the oil (microdieseling), and electrostatic spark discharge leading to localised hotspots in the oil and therefore decomposition. The decomposition products are often insoluble in oil and therefore precipitate out as sludge or plate out on surfaces as varnish. The choice of base oil is also influential as solvent extracted,

hydrocracked and hydrotreated oils can have very different abilities to solubilise additives as well as additive decomposition products. Design features of the turbine itself, such as arrangement of the lubrication and hydraulic circuits, proximity of bearings to high temperature zones, and the maintenance practices applied also have a significant impact on problems due to varnish and deposit formation.

Some solutions for varnish issues have emerged. A large amount of effort has been put into developing superior condition monitoring technologies. Traditionally, the condition of an oil and propensity for forming deposits was predicted easily by tracking oxidation-related parameters such as acid number and viscosity of the in-service oil. However, with the increased availability of hydrofinished base oils, which enable oxidation lifetimes up to an order of magnitude higher than possible with solvent extracted base oils, deposit formation can occur before any noticeable changes in the viscosity and acid-number profile. Novel condition monitoring methods such as Membrane Patch Colorimetry ASTM D7843 offer the ability to predict varnish formation reliably. Improved maintenance procedures have also been advocated. Heat-tracing of pipework to minimise sharp temperature drops and therefore minimising precipitation by sudden cooling, use of advanced filtration systems with optimised filter materials, use of electrostatic precipitators and ion exchange technologies in conjunction with appropriate condition monitoring have met with success in reducing varnish-related downtime for turbine end users. As formulators of additive technology for turbine oils, Afton Chemical sought through this study to investigate the effect of the oil formulation, in other words the combination of additive chemistry comprising of antioxidants, metal deactivators, corrosion inhibitors, etc. with base oils, on the potential to form varnish and related deposits.