VARNISH FORMATION IN GAS TURBINES FROM MINERAL-BASED AND PAG-BASED LUBRICANTS

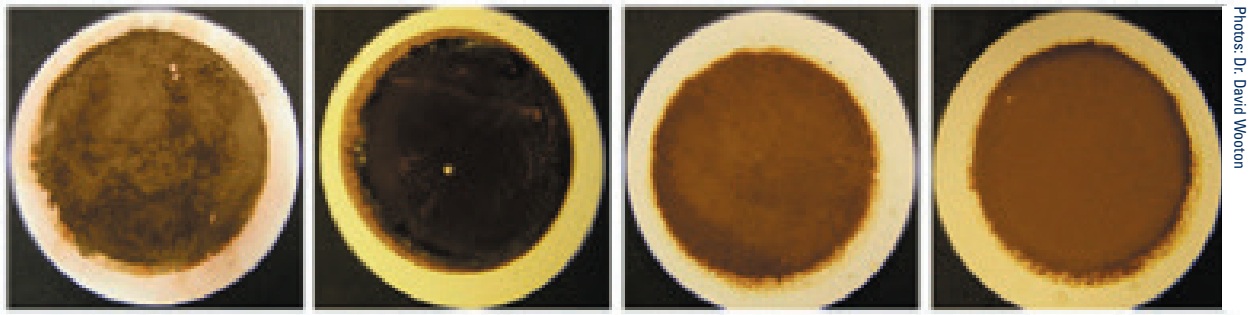
Varnish created by lubricant oxidation in gas turbines is a major concern for power generation companies. Varnish can cause gas regulation valves to stick and impair oil cooler performance, resulting in serious operational issues or, in the worst case, an automatic shutdown or failure to start. Lubricant producers are responding to the demand to deliver products that mitigate varnish problems before they occur.

The industry has recently seen the introduction of polyalkylene glycol or PAG-based turbine oils. Some of these are purported to be "varnish free." However, testing by Dr. David Wooton, an independent lubrication and technical consultant, calls these claims into question.

Dr. Wooton conducted a series of 10 industry-standard ASTM tests comparing PAG-based and mineral-based turbine oils.[1] The fluids studied included a PAG formulation and three different mineral oils representing older, newer, and premium formulations. Testing included both off-the-shelf and in-service fluid samples.

Though the tests analyzed many performance factors, they did shed some light on the issue of varnish formation from mineral-based

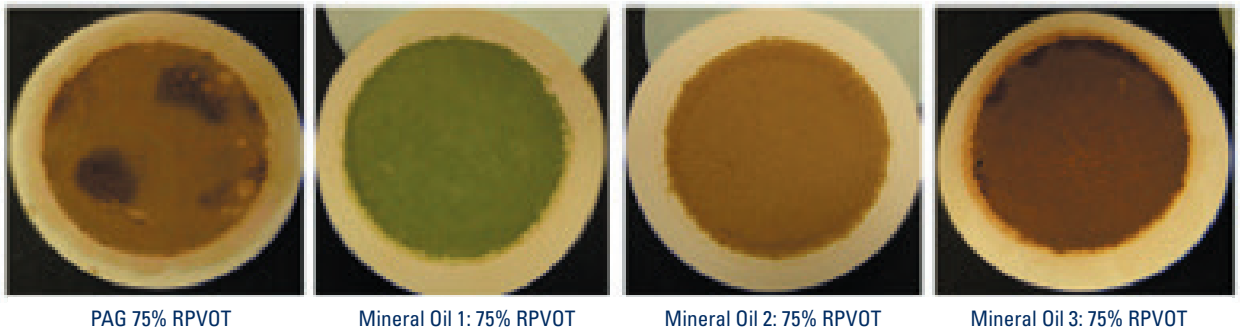
MPC Patch Test Results



Photos: Dr. David Wooton

PAG RPVOT EOT | Mineral Oil 1: RPVOT EOT | Mineral Oil 2: RPVOT EOT | Mineral Oil 3: RPVOT EOT

MPC Patch Test Results with 25% of the RPVOT Time Remaining



PAG 75% RPVOT | Mineral Oil 1: 75% RPVOT | Mineral Oil 2: 75% RPVOT | Mineral Oil 3: 75% RPVOT

oils compared to PAG oils. A key focus of the study was oxidation, the primary cause of degradation and varnish formation in turbine lubricants. The most widely accepted bench test for oxidation is ASTM D2272, the "Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel (RPVOT)."

Dr. Wooton performed experiments using the D2272 to determine the fluids' propensity to oxidation. At the end of the D2272 test, when the fluids reached 25% of "new fluid values" (roughly the time when a lubricant change is recommended), the mineral oils and the synthetic-PAG fluids showed similar, failing-to-critical varnish levels.

He then subjected the in-service fluids to the ASTM D7843 MPC test, considered the industry standard for measuring propensity to varnish production. The results showed that the varnish levels were lower than expected, but still considered critical. Based on the varnish formation levels, change would be recommended for all four fluids.

D7843 (MPC) Results

Testing Series	MPC D7843 (dE)
PAG: 25% RPVOT	65.5
Mineral Oil 1: 25% RPVOT	54.9
Mineral Oil 2: 25% RPVOT	61
Mineral Oil 3: 25% RPVOT	74.6

In summary, the PAG fluid was not "varnish proof," but performed very similarly to mineral-based oils on measures of oxidation and varnish formation. Dr. Wooton further concluded that, "When varnish starts to form in this PAG fluid, one would expect it to form reasonably quickly, while the mineral oil formulations would form varnish at a gradual rate." In either case, a change would be recommended when the fluid reaches 25% of new oil value.

[1]Wooton, David, "How to Evaluate a New Lubricant, Machinery Lubrication, October 2017 https://www.machinerylubrication.com/Read/30938/evaluate-new-lubricant