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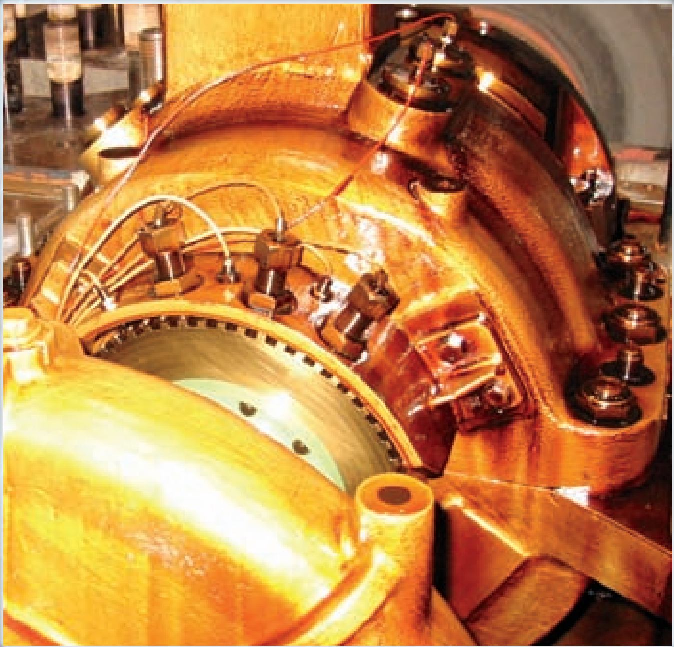

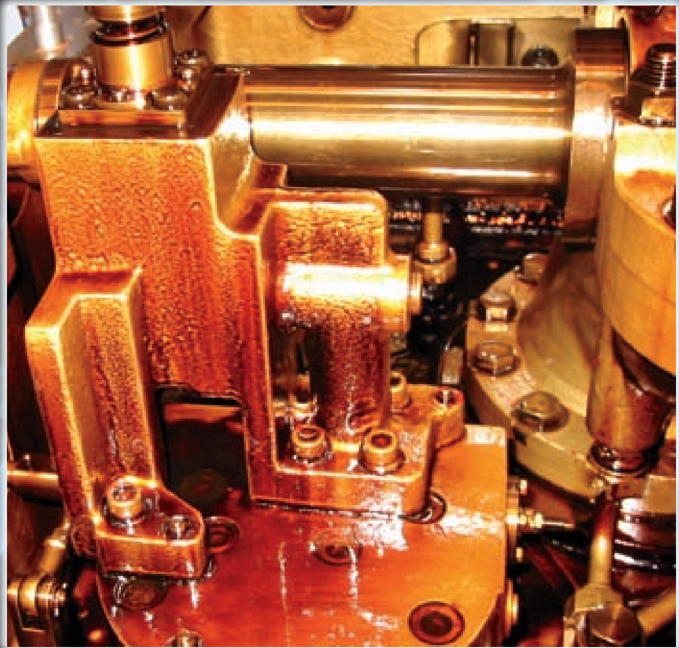

Get turbine varnish under control

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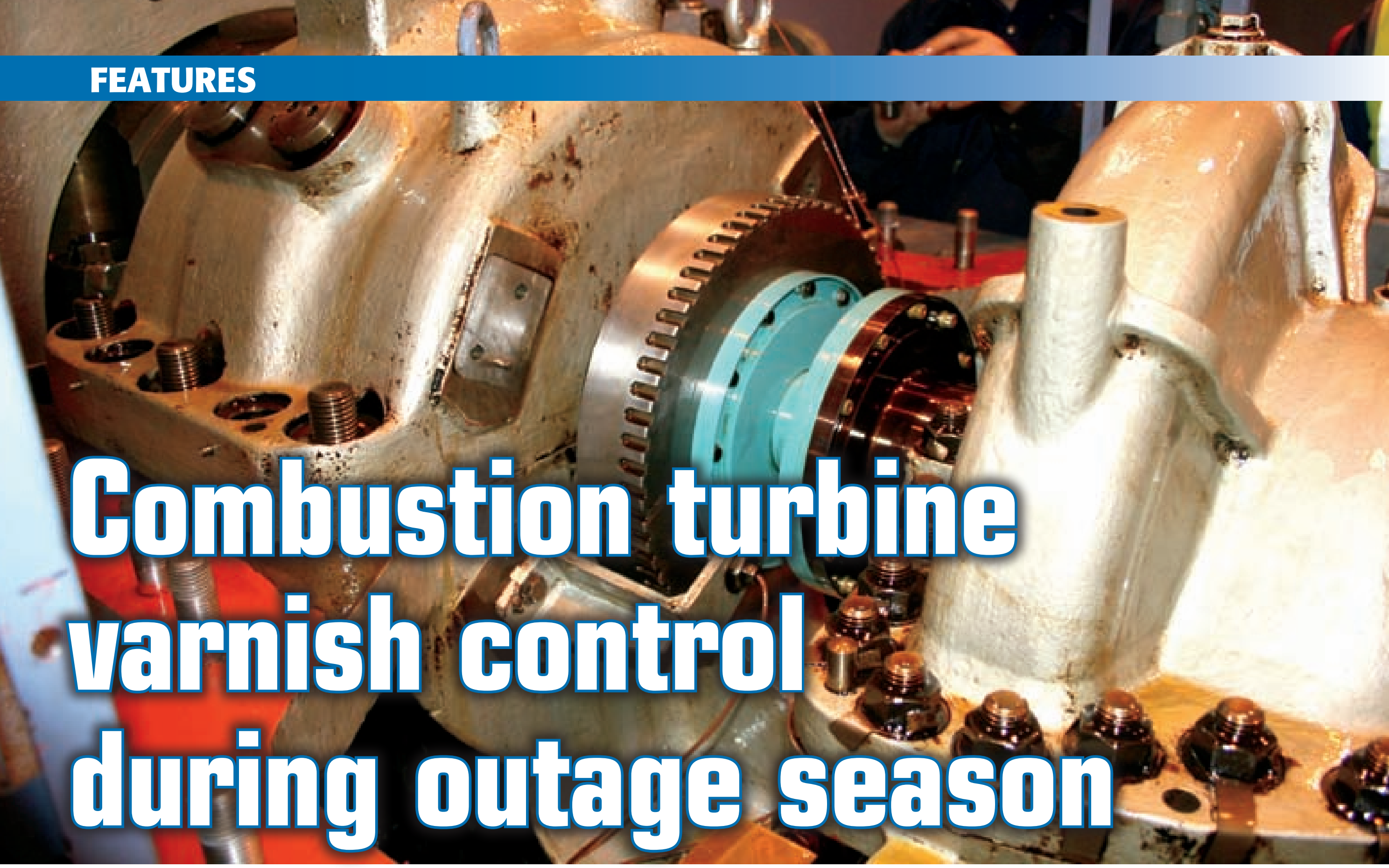


Combustion turbine varnish control during outage season

By Brad Buecker and Kal Farooq

Much of the power produced in this country, at least for peak load purposes, comes from either simple- or combined-cycle combustion turbines. A problem that is becoming increasingly common, or perhaps more fully recognized, with these units and at base load plants is varnish formation in turbine lube oil and fluid hydraulic systems. Varnish forms a sticky coating on surfaces inside the fluid system, including bearings, coolers and valves.

Current varnish control technologies have met with very mixed success, and plant personnel at some locations have been forced to perform fluid system cleanings either during scheduled maintenance outages or in a forced-outage situation caused by the varnish itself. A cleaning might be performed, only to have varnish begin causing problems within a matter of months. This article examines varnish formation fundamentals, difficulties derived thereby and a very promising control method.

What causes varnish?

Advances in gas turbine design and/or operational changes have, in many cases, increased the stress on lubricating fluids. These changes include higher operating temperatures, smaller fluid reservoirs, increased cycling, use of more highly refined fluids that have a lower solvency for varnish-forming compounds and use of finer filtration that increases the electrostatic charge on the fluid.

Lubrication fluids, of course, consist of hydrocarbons with additives included to give a particular fluid the desired properties for a particular application. While the additives are designed to reduce fluid breakdown or polymerization, such chemical changes cannot be entirely eliminated, particularly in systems where the fluid is subject to thermal or mechanical stresses. A variety of stresses are placed on turbine fluids during operation, the most pronounced of which are:

- Oxidation
- Filter-related electrostatic discharge
- Micro-dieseling, adiabatic compression

The last two items call for some additional explanation. All lube oil systems are equipped with filters to remove particulate contamination. As fluid flows through the filter media, its passage results in separation of charges between the fluid and the media, similar to what happens when you rub a balloon on your shirt to give it static electricity so it will stick to a wall or ceiling. At a certain point, the accumulated electrical potential will discharge to the nearest surface of lower potential. This discharge occurs as high-energy electrical arcing that damages the fluid and produces varnish precursors.

Compression of air bubbles in the fluid at a fast rate, such as at the inlet of a high-pressure pump, causes a rapid increase in fluid temperatures. Very high temperature at the point of bubble collapse initiates thermal degradation of the fluid, resulting in formation of resinous, varnish-forming materials.

The trouble with varnish

The semi-soft varnish particles that form via the mechanisms outlined above have limited solubility in the fluid and tend to settle and form a thin deposit on such components as pipes, tanks, bearings, heat exchangers, servo-valves and other components.

Thus, the deposition can cause reduced heat transfer and operational failure of system components. Stiction of the servo-valve spool is most problematic, causing turbine start-up and control problems.

Varnish also accelerates bearing wear by capturing wear particles due to its sticky nature, and varnish deposits reduce thermal dissipation in bearings, heat exchangers and tank surfaces. In extreme cases, shutdown of the system to clean varnish deposits might be required, costing many thousands of dollars in labor and lost electrical production.

Figure 1. Electrostatic discharge-induced arcing in a fluid filter. Photo contributed by Pall Corporation.

Varnish control

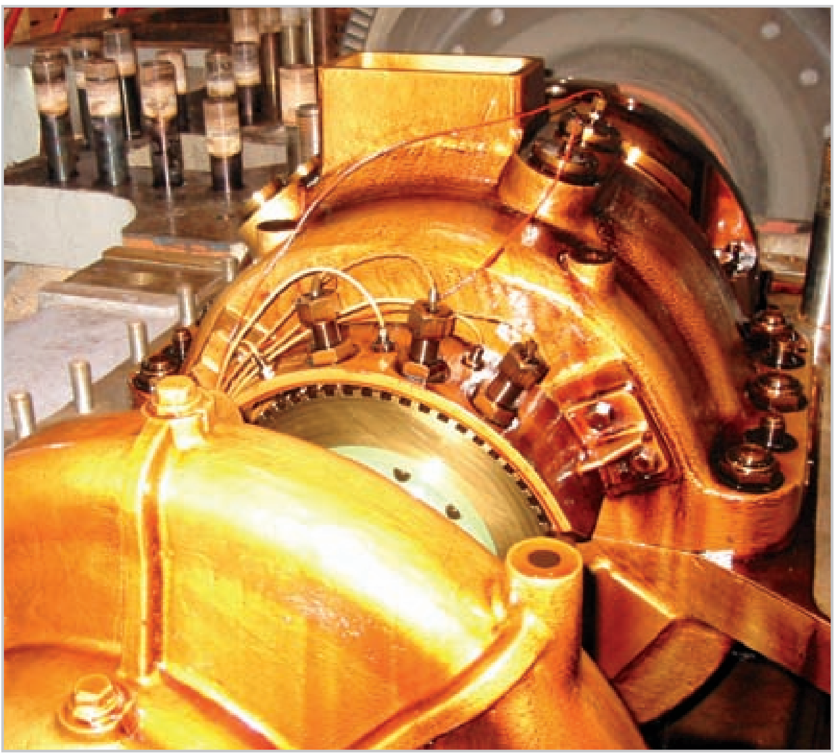
The removal of varnish from an operating turbine lubrication and control fluid system usually entails treating the fluid to remove varnish-forming material suspended within the fluid. Even though varnish is only slightly soluble in the fluid from which it comes, if the soluble portion can be removed continuously, many of the remaining deposits will gradually re-enter the fluid. The most common method for varnish removal to date has been electrostatic precipitation (ESP). These devices subject the fluid and the varnish particles to an electrical field, causing them to agglomerate and to either be captured by a filter mat or be collected on an oppositely-charged surface. ESP has shown some mixed results in regard to its ability to remove varnish, with some reports saying that high water concentrations and/or excessive metallic debris will cause operational problems with these devices.

A removal technique employed for excessive varnish formation is off-line cleaning. This involves flushing the system with specialty chemicals to soften and dislodge the deposits, which can then be removed by disposal of the cleaning fluid. A follow-up flush with clean fluid is then employed to ensure complete removal of the chemicals. The process can be effective, but obviously an off-line cleaning, which can take several hours to several days, requires that the unit be down and producing no electricity. Thus, the process is both time consuming and costly. Costs for the flushing process alone can exceed $100,000 for a Frame 7 turbine. Furthermore, some utilities have reported rapid varnish buildups just months after a cleaning.

The above examples illustrate that continuous varnish control can be quite profitable.

A method that has been employed for varnish removal is the adsorption process, which utilizes high surface area fibers in filter cartridges to contact the fluid and capture/retain varnish materials. This technology has been used for some time and now Pall Corporation developed a media that is engineered and treated with special binder resins to give the material a pronounced affinity for varnish removal, but without attracting the fluid additives.

Laboratory testing and field trials on operating turbines have shown consistent, high varnish removal from several types of fluids. The process involves kidney-loop filtration of the fluid in the main reservoir, while the turbine



Varnish problems at a power plant in Iceland were brought under control with an ESP system from OilKleen. The cleaned systems are shown on the left. Photos contributed by OilKleen.

Varnish Potential Rating (VPRSM)	Condition
<35	Normal
38-58	Active monitoring should be implemented
60-79	Abnormal
>79	**Critical** Immediate action needed

Currently, the most widely used method for determining varnish formation potential in a system is based on colorimetry. The procedure involves filtration of the oil sample, after first being blended with a solvent, on an analysis membrane that collects the varnish-forming material to produce a distinct color. The color composition and intensity are then utilized to determine colorimetric values based on a proprietary algorithm. The following table lists calorimetric values based on the QSA test by Analysts Inc. and outlines the data's significance in terms of fluid condition and the company's recommended actions.

A well designed and functioning varnish removal system should reduce the VPR to well below the "normal" value of 35. *QSA and VPR are registered service marks of Analysts Inc.*

Figure 3. Example of an 11 gpm Adsorption Process Varnish Remediation System. Photo contributed by Pall Corporation.

is producing power or on turning gear. Depending on the condition of the fluid and the volume of varnish deposits, the time required to clean up a system varies, but has been shown to be significantly faster than existing methods. For example, a Frame 7 turbine with a 6,200-gallon fluid system saw a reduction in the Varnish Potential Rating (VPR^{SM}, see sidebar) of 85 to 18 within 7 days. A fluid sample obtained from the turbine 2 months later, with the varnish removal system in continuous service, exhibited a similar, very low VPR.

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