Beware of varnish deposition

ELECTROSTATIC CLEANING METHODS CAN REMOVE PRODUCTS OF LUBRICANT OXIDATION

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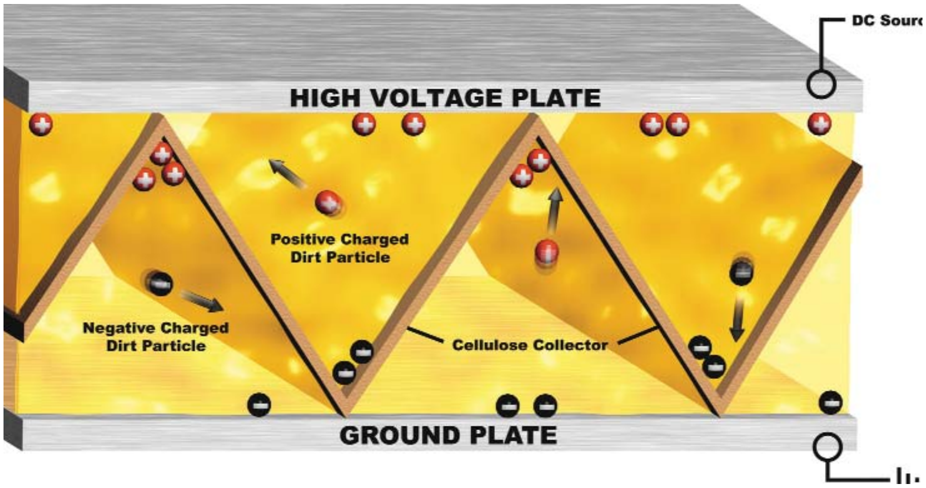

Figure 1: Cellulose collectors in the electrostatic cleaning system replace mechanical filters

As gas turbines run, friction and heat combine to degrade lubricant oil. Small degradation byproducts settle throughout the system as varnish. Over time, these particles attach themselves to surfaces throughout the turbine producing a sticky coating. As varnish builds up, turbine performance suffers.

Left untreated, varnish causes a multitude of performance-critical problems including increased bearing wear, accelerated gear wear, lowered performance of heat exchangers, and, most critically, valve stiction (stick and friction). Stiction is a condition in which the force required to move a valve increases.

Fuel control and inlet guide vane valves are particularly susceptible to varnish build-up, causing trips and unplanned outages. Finally, the oil needs to be changed frequently.

Electrostatics can solve varnish problems in gas turbines and extending oil life. Although this technology has been used for years in industries, such as pulp and paper and injection molding, it has only recently come into favor in power generation.

The impact of varnish

As your machine runs, a chemical process called oxidation occurs, forming tar, varnish and sludge (Figure 2). Varnish acts as a catalyst to shorten lubricant life.

Tar and varnish are sticky substances that adhere to component surfaces causing "stick and slip" and additional wear. In addition, the tacky nature of varnish attracts other contaminants, converting smooth metal surfaces to sandpaper.

Varnish is a result of the base oil and additive system deteriorating in the lubricant. Heat, an unavoidable factor, is among the biggest enemies of turbine oil and is a primary factor in the creation of degradation byproducts. When oil temperatures reach above 300°C the hydrocarbon molecules begin to crack and break apart, polluting the lubricant. Beyond general heat-related degradation, there are at least six additional root causes of varnish in gas turbines. They are:

- Static discharge from mechanical filters
- Shared reservoir for hydraulic and lube oil circuits
- Hot spots in the system
- Water contamination
- Implosion of air bubbles
- Base oil changes in turbine oils

Products of oil oxidation coat the hydraulic servo, proportional, and cartridge valves forcing the friction in these valves to increase. The change in friction in these highly sensitive, close-tolerance components causes unwanted effects, such as:

- Loss of control stability
- Control valve failure
- Reduced machine performance
- Increased downtime

Of concern to reliability engineers is the fact that the onset of varnish cannot be predicted with routine oil analysis. Lubricants with a low particle count and acid number, and a high RPVOT value (a measure of oxidation resistance) are also vulnerable to varnish. Both newly commissioned turbines and older installations are susceptible to these varnish-related failures.

Prior to the development of electrostatics, the predominant technologies for removing contaminants in hydraulic oil were detergents and mechanical filters. Mechanical filters are capable of filtering contaminants of 1 micron size.

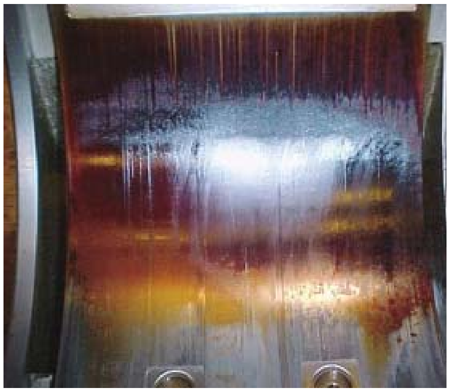

Figure 2: Varnish can accelerate the wear of components and cause valve stiction

While filters are capable of removing some of the solid partcles, polymerized oil oxidation products are as harmful as solid particles. The oxidation products are of molecular size and cannot be removed by mechanical filtration.

Further, mechanical filters generate static electricity when oil passes through filter media. This can accumulate in either the filter or oil and cause spark discharges and accelerate oil oxidation, as the temperature of spark discharges can be as high as 10,000°C. Oils will deteriorate at such high temperatures and oil deterioration can cause hydraulic system failures. However, electrostatic oil cleaners can remove not only micron size particulate contaminants but also polymerized oil oxidation products.

How electrostatics works

Contaminated oil is passed through a high voltage (10 - 15 KV) that charges the suspended dirt particles. The charged particles are pushed towards the positive and negative electrodes. Contaminants are then entrapped in a collector.

Some electrostatic cleaning methods use the concept of particle agglomeration. A high charge is passed through the oil, quickly agglomerating the particles, and the enlarged mass is caught by the mechanical filter in the lube oil circuit.

However, this process may lead to other problems. For instance, the operator will still have to deal with clogged filters in his system. The applied charge that remains on the particles keeps them combined, well after the fluid passed over the electrodes. This creates a host of potential problems, such as erratic, unpredictable particle agglomeration in unwanted areas of the lubrication system, or accelerated oil oxidation. Of even greater concern is a release of the accumulated charges in the form of a spark, causing additional oxidation and varnish to form.

These problems can be prevented by locating the electrostatic cleaners external to the main lube oil circuit. A separate loop incorporating the electrostatic device draws oil from the main reservoir and circulates it at low velocity (0.5 gpm to 5 gpm). The charged particles are drawn to the positive and negative electrodes. Neutral contaminants are drawn and deposited by gradient force. These contaminants are trapped on a cellulose collector for easy disposal (Figure 2).

In this design no mechanical filters are used to remove polymerized particles. As mentioned above, traditional mechanical filters remove only large particles, while electrostatic systems remove large as well as sub-micron contaminants from any non-conductive liquid. This means only insoluble oil contaminants are extracted. Soluble additives present in the oil are not affected.

In addition, the external system works continuously, constantly removing contaminants from hydraulic fluids and lubricating oils. Further, this form of electrostatic oil cleaning can clean system internals. Rather than depositing varnish over time, the oil cleaned by electrostatic methods strips away the varnish, one molecular layer at a time.

Systems with severe varnish contamination can be reclaimed. Valve stiction problems can be eliminated in gas turbine systems in 14 days after installing the electrostatic system.

Finally, these systems run virtually maintenance-free, requiring only a periodic collector change. The collector is typically housed within a stainless steel chamber. Depending on the application, the collector can provide continuous operation from 4,000 to 10,000 hours of use.

Author

Doug Muennich has more than 20 years experience as a lubrication engineer in industrial lubricants. He currently leads the varnish removal technology efforts with UAS/Kleentek (www.kleentek.com). Muennich has spent the last four years studying the products of oil oxidation and the formation of varnish with. Akira Sasaki of Kleentek Ltd Japan.