Particulate contamination in industrial machine lubricants such as compressor oils and hydraulic fluids is an ongoing problem that threatens a machine's ability to operate at optimal levels over a long time frame. The main problem is that particulates slowly and silently cause mechanical wear on the machinery. Coupled with water contamination, this process can lead to corrosion of metal surfaces and accelerate the oxidation of the lubricant.

Two types of wear mechanisms are prevalent in industrial systems. Abrasive wear involves particles entering the layer between two sliding surfaces separated by a thin lubricant film. The particles can rub and scrape both surfaces leading to increased wear. Particle size is very important in this process as only those contaminants that are equal or slightly larger in size than the thickness of the lubricant film will cause the wear. Much larger particles will not be able to enter the space between the surfaces, while smaller particles will pass right through and not impinge on the surfaces.

The size of contaminant particles also plays a role in fatigue wear. In this case, particles larger than the thickness of the lubricant film can contact the sliding surfaces and create dents and microcracks. Eventually, these microcracks will grow and spread until the surface becomes undermined, leading to failure with the concomitant release of more wear particles. Adhesive wear is the next stage that surfaces face once damaged by abrasive and fatigue wear. At this point, asperities have developed on the two sliding surfaces that can contact the other surface leading to seizure and welding. This metal-to-metal contact is extremely damaging and can eventually cause catastrophic failure.

IMPORTANCE OF SMALL PARTICLES

The gap between sliding surfaces in machinery components such as journal bearings, gears, vane pumps and engines can be quite small. Average clearances have been found to be between 0.1 and 500 microns. Most conventional filtration equipment is effective in removing particulate down to the 10-micron range. Fine filtration systems are effective in catching particles between 3 and 5 microns in size.

Particle size analysis of contaminants typically found in lubricants shows that over 50% range in size from 0.1 to 5.0 microns. One other critical element is hardness. This parameter is important because the harder the particle the greater the chances of causing wear when striking a metal surface. There is an indirect relationship between particle hardness and size. This means that the harder particles tend to be smaller, falling within the 0.1-to-15-micron range.

Much of the discussion about particles so far has centered on those of metallic origin. But small particles also can be generated from decomposition of the lubricant.

“Excessive heat, water contamination, aeration and metal particles can oxidize the lubricant leading to the formation of oxide..."
insoluble particles” says Gerald Munson, chief technology officer for ISOPur Fluid Technologies. These chemically insoluble particles tend to be highly polar in nature and are small (one micron in size). They tend to be attracted to the surface of machinery that is also charged. This sets the foundation for the formation of varnish, as more particles will adhere to the surface. Once water is introduced into the system, the varnish can easily turn into sludge.

BALANCED CHARGE PURIFICATION

ISOPur Fluid Technologies has developed a process to remove these small particles by providing a balance of positive and negative charges and then allowing the opposite charges to attract. The result is an agglomeration of the particles into a larger size. The process is called Balanced Charge Purification.

“The key to the process is to separate the fluid into two streams and charge the particles with an equivalent amount of positive and negative charge to ensure that the overall system becomes neutral,” says Munson.

In effect, Balanced Charge Purification neutralizes a charged system, enabling the balanced distribution of negative and positive particles to attract and combine into larger particles. Details on this patented technology can be reviewed in U.S. Patent 5,788,827, published in 1998.

Electrostatic processes also utilize charging of particles to achieve purification. However, these processes involve charging all of the particles either negatively or positively and then using a grounding plate with the opposite polarity to isolate them from the system.

“One of the problems with this approach is that high voltages—between 75,000 and 100,000—are required,” says Munson. “In contrast, Balanced Charge Purification is much safer as it requires a low voltage between 10,000 and 15,000 volts, which is much more user friendly.”

A picture of a typical Balanced Charge Purification Unit is shown in Figure 1. Newly combined particles can then be removed by conventional, mechanical filtration techniques. Charging can be done successfully because the extremely severe, high-flow conditions force particles to come in contact with the electrodes. Munson believes that sufficient numbers of oppositely
charged particles are available to attract.

Electrical charges can also be bumped from one particle to another. Munson says, “Larger particles will tend to bump into more particles and transfer their charge more often than smaller particles. The result will be that the charges will more likely end up on the smaller particles.”

While particles are being charged, mineral oil, which is a hydrocarbon, remains neutral and is not affected. Other lubricant basestocks are in the process of being evaluated. Munson indicated that polyalphaolefin (PAO) behaves in the same fashion as mineral oil. Testing is ongoing with lubricants based on polyol esters, diesters and polyalkylene glycols (PAGs). This testing has been underway for 12 to 18 months, but Munson has deferred any comment until the trials are completed.

ISOPur’s Balanced Charge Purification is effective with water concentration levels up to 20%. A coalescer is recommended to remove water from the lubricant. Regarding emulsion systems, Munson says, “Our product technology is not designed to operate on oil and water emulsions used for machining and for high-pressure hydraulic power and control.”

CASE STUDY: COMPRESSOR OIL
A manufacturer of 3,000-hp compressors was facing difficulty with varnish buildup in units used to maintain pressures in gas pipelines. The compressor oil was relatively clean, but the compressor supplier was concerned that the extremely high-speed use of its equipment could lead to operating problems. Varnish buildup on a shaft and bearing is furnished in Figure 2. The varnish was attributed to the presence of small particle contaminants in the compressor oil.

The compressor manufacturer consented to using ISOPur’s Balanced Charge Purification Technology in a trial started in March 2001. Figure 3 shows a graph which provides data for the type and concentration of particulate over the length of the seven-month trial. Most of the contaminants are in the 2-to-5-micron range in size. Initially, a month’s worth of baseline data was collected prior to starting up the ISOPur unit. Figure 4 shows the compressor shaft and bearing varnish-free.

This trial shows the three phases of purification typically seen with the ISOPur system. In Phase 1 an immediate reduction in particle count was observed after the ISOPur purification system was engaged in mid-April 2001 to clean the compressor oil. As the clean oil encountered sludge and varnish in the machinery, a second phase of scouring was initiated to clean the compressor. The level of particulate initially rose from late May into early July during this phase as the contamination on machinery internals was pulled into the fluid to be removed. This led to fluctuations in particulate concentration.

The benefits of the Balanced Charge Purification were clearly seen once the unit was shut down for one week in early August and then resumed operation through mid-October. In Phase 3 the particle count, which rose dramatically during shutdown, returned to lower levels as the ISOPur unit
removed particulate generated during scouring. Munson says, “This three-phase approach is a slow but necessary process to protect the system against the hard particulates found in the machinery. There is a distinct risk of damage if these particulates are freed too quickly from the machinery.”

One month after the end of the trial, the shaft and bearing shown in Figure 2 were re-evaluated as pictured in Figure 4. Both parts are almost completely rid of varnish. An evaluation was also made about the type of contaminants removed by the ISOPur unit. Prior to use, the main source of contamination was found to be organic in nature and not metallic. Evaluation of residue collected in the mechanical filtration units was consistent with this finding, meaning the ISOPur unit was acting to remove the main source of contamination.

**CASE STUDY: GAS TURBINE OIL**

A relatively new gas turbine unit needed overhauling after only five years of operation due to bearing wear. This unusual action was necessitated because of the extremely high levels of small particulates that led to the formation of varnish and sludge. The concentration of particulate in the lubricant was excessively high—just over 730,000 particles per milliliter of lubricant. More than 95% of the particles were fine particulate, between 1 and 5 microns in size.

Once the turbine unit was restarted with fresh lubricant, the contamination problems resumed with a particle count of nearly 11,000 per milliliter of lubricant obtained in a short period of time. An ISOPur purification unit was installed and reduced the particulate content in the gas turbine oil in one month to a level exceeding the cleanliness of virgin lubricant. The gas turbine system utilized the ISOPur technology for a two-year period. During that time, the particle count dropped to 1,265 per milliliter of lubricant. The particle count as measured by the ISO System dropped from ISO 21/19/16 to ISO 17/15/11.

The gas turbine unit has operated for three years without any difficulty. The end user realized stable operating conditions, lower operating costs and reduced down time. In fact, the success of this trial has prompted the end user to order additional ISOPur purification units for other gas turbines used in the plant. <<

---

Reach a new level of oil purity.

**The ISOPur Return:**

- Extend oil & equipment life
- Minimize downtime
- Reduce waste oil
- Eliminate varnish/sludge

IsOPur’s unique, patented Balanced Charge Purification (BCP) technology places a positive and negative charge on sub-micron fluid contamination. The particles grow in size and are then easily removed, eliminating sludge and varnish along the way.

---

IsOPur™ Fluid Technologies, Inc.

The power of purity.

ph: 860.571.8590  
t-free: 888.270.9889
fax: 860.571.8815
www.isopurfluid.com

Germany, Italy, China