Gearbox Condition Monitoring through Used Oil Analysis

Demonstration in Proven Reliability and Continued Cost Savings
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This case study summarizes continuing cost saving benefits to the City of Ft. Collins, Colorado, through the development and implementation of a comprehensive, proactive used oil analysis maintenance strategy for the planetary gearboxes on domestic wastewater anaerobic sludge dewatering centrifuges.

Two of these machines were installed new circa 1998, at a purchase cost of $619,000 each, to replace existing sludge dewatering belt filter presses. These machines were complex by comparison, requiring additional research in order to become familiar with the proper maintenance that would be required to ensure many years of cost-effective, reliable service. One area of my responsibility as a Maintenance Specialist for the Water Reclamation and Biosolids Division was to determine and create the appropriate maintenance tasks for this new equipment. I knew that a reactive maintenance strategy would be unacceptable, as this would eventually prove to be the most costly maintenance approach.

I began by reviewing the manufacturer’s maintenance recommendations and guidelines. Being very familiar with preventive maintenance strategies, I believed that the proper gear oil level would need to be maintained and that a complete oil change would be recommended after a certain amount of runtime and/or calendar based time. The manufacturer’s lubrication schedule required an annual oil drain and replacement of the gear oil, for service duty of one shift per day. The quantity and type of oil required is 15 quarts of the manufacturer’s synthetic gear oil part number 9CH48. The manufacturer also suggested a “gearbox exchange program”, in which every two years the gearbox would be replaced with a factory reconditioned gearbox. The exchange cost was estimated at $8,000 per each, not including labor.

After additional research and study, I began wondering if there could be a way to extract a representative used oil sample from these gearboxes for oil analysis. Our oil analysis program was very young at this time, and at this stage most everything was experimental. I was new at learning that if we
could know the condition of these gearboxes i.e. – through an impending wear predictive strategy or better yet, a root cause analysis proactive strategy, we could begin to monitor and detect symptoms of early impending failure. We could identify and eliminate, or at least attempt to control root causes of these detected symptoms. Ultimately, we may be able to extend oil drains and reduce the associated maintenance costs with less generation of used oil and less need for new oil replacement. We would have a better understanding of the condition of our new gearboxes, while increasing reliability and reducing maintenance costs.

These centrifuges are mission critical to the Water Reclamation and Biosolids Division. The belt-filter presses have since been decommissioned, though technically they are on standby as back-up. However, for various reasons beyond the scope of this writing, start-up and re-use of these filter-presses is not favored.

Each centrifuge has a bowl assembly that is v-belt driven by a 300 HP AC induction motor at approximately 1748 RPM. The driven bowl speed is roughly 2800 RPM. There is a back-driven scroll assembly within this bowl, rotating at approximately three RPM less than bowl speed. The scroll regulates the rate at which the dewatered solids exit the machine, in order to obtain an optimum percentage of dewatered bio-solids. The scroll is driven by a back-drive system which consists of a 100 HP DC motor, synchronous belt-drive turning the planetary gearbox. Average service duty is approximately six to ten hours per day, four to five days per week. Loss of one of these centrifuges would mean extended hours of operation for the remaining centrifuge and additional extended labor hours for the operations staff.

Due to the planetary design of these gearboxes, it is not possible to obtain a representative oil sample during normal operation, and extracting the sample is not conventional. A small rigid brass pipe nipple was fabricated in to a gearbox oil plug to provide a means of collecting the sample by gravity to an ultra-clean sample container, provided by a commercial, off-site oil analysis lab.
The sample is collected immediately after shut-down. If the sample is not collected within 30 minutes of shut-down, the gearbox outer shell and input shaft are manually rotated numerous revolutions before flushing the sample collection fitting, and collecting the sample.

After frequent initial sampling to establish baseline data, the sample frequency was set at quarterly, and later updated to 500 hours of operation, with the implementation of an hour meter installed on the drive motor instrumentation.

Representative used oil samples, as well as new oil samples, were collected and labeled with all pertinent data and sent to the oil analysis lab. The new oil samples would provide a means of determining the physical properties and additives within the oil. Cleanliness targets were determined and set at ISO 16/13.

All of the lab’s oil analysis reports and recommendations were reviewed very closely to monitor the oil’s physical properties, any contamination, and/or wear metals.

I did not replace the oil at the manufacturer’s suggested one-year run-time interval because the oil analysis reports continued to be favorable. ISO cleanliness was diligently maintained through off-line kidney loop filtration using micro-glass Beta 75 - 10µm filters. The lab’s oil analysis test slate included a variety of typical tests including ISO cleanliness, kinematic viscosity at 40°C and 100°C, water by Karl Fischer, total acid number (TAN) & elemental spectroscopy.

As the two year maintenance interval approached, still seeing no data-driven reason to replace the gear oil, let alone to “exchange the gearbox”, I suggested that we contact the original equipment manufacturer, regarding our maintenance strategy, and ask whether it was acceptable in their sight, and whether they would still recommend “exchanging” our gearboxes. In a conference call to their maintenance engineering group, I informed them that “we maintain an ISO 16/13 cleanliness standard, (with ISO 4406:99, this became 18/16/13), we monitor the oil for
physical properties including oil viscosity and water by Karl Fisher, we trend Total Acid Number. We monitor for external contamination ingress, and keep a close watch on contamination, additive depletion & wear metal trends. We are focused on a proactive, condition-based maintenance strategy. Their response was “…you are doing what no other customer of ours currently does. I’d keep it up. The exchange program is not necessary with this comprehensive strategy.”

Now fast forward to 2013. These original two planetary gearboxes are still in service. All parameters continue to be diligently monitored. The original oil (part number 9CH48) was replaced with a major brand, ISO VG 220 - PAO synthetic gear oil, after we ran out of the originally supplied ten gallons of part number 9CH48 oil that came with the new machines. Using the original estimate of $8,000 per gearbox at two year intervals, this cost savings compared with reconditioned gearbox purchases alone totals over $112,000. Though I am now a Reliability Specialist with Pioneer Engineering and no longer in the capacity of maintaining these centrifuges and gearboxes, the City of Ft. Collins’ proactive oil analysis maintenance strategy continues today in the capable hands of the competent Water Reclamation and Biosolids Division maintenance staff. Their skilled craftsmen continue to employ proactive maintenance strategy with these gearboxes and many other assets within the division. On several occasions, in order to thoroughly clean the internal cavities of these machines, the maintenance staff has completely disassembled, thoroughly cleaned and rebuilt each of these centrifuges, over the course of the severe service duty, that each of these machines has incurred, saving the city tens of thousands of dollars, time and again, had the work been contracted to an outside source. Through it all, the planetary gearboxes have been removed, and re-installed, without the need for replacement or disassembly.

The comprehensive used oil analysis program, a proven reliability centered, condition-based, proactive maintenance strategy, includes many other assets within the Water Reclamation and Biosolids Division, many worthy of their own testimonial, however the proven strategy with these two planetary gearboxes, speaks for itself.