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A NEW APPROACH TO MAINTAINING INDUSTRIAL EQUIPMENT

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When it comes to the life of any machine, cleanliness counts. Moisture, air heat and hard particles are all detrimental to fluid systems. Acting alone or in some combination, these factors are the root causes of most fluid system failures. Of these four root causes, particulate contamination – the population of abrasive solids (dirt, metal and other particles) found in fluids – is the prime enemy. A survey of industrial plant facilities uncovered that" .... between 50 and 75 percent of hydraulic system failures are a direct result of fluid contamination".

Costly particulate contamination slowly degrades and jams machine components causing product defects, shorter machine life, increased production downtime and decreased energy efficiency. Even the smallest amount of water, or the most microscopic particles, can eventually grind a machine to a halt. Yet, maintenance has historically been a reactive type activity. When a machine breaks down, maintenance personnel give the failed components the "4R Treatment" – that is remove, repair, rebuild and/or replace. When evidence suggests that material degradation and/or deterioration is taking place at an accelerated rate, the cause has been determined and action taken to correct the problem.

In today's world when there are increasingly complex systems, maintenance personnel must supplement such traditional reactive maintenance practices with proactive methods that can identify aberrant root causes of failure long before materials or component performance degradation occurs. No maintenance discipline has previously taken the micro view on machine damage – concentrating on the causes instead of the symptoms of wear. Proactive maintenance is that discipline, and it is quickly being recognized worldwide as the most important means of extending machine life.

PROACTIVE VS. PREVENTIVE/PREDICTIVE MAINTENANCE

Preventive maintenance, when used correctly, has been shown to produce maintenance savings in excess of 25%, but beyond this, its benefit quickly approaches a point of diminishing return. Preventive maintenance requires visually inspecting the fluid condition plus analyzing chemical composition of the fluid. It also requires internal and external leakage assessment of the system under extreme operating conditions to obtain evidence of wear, pressure, flow, and temperature data under realistic operating conditions to assess slippage and dynamic leakage. But many studies have proved that the guess work involved in preventive maintenance practices render it inefficient. In fact, according to a Forbes magazine article, "one out of every three dollars spent on preventive maintenance is wasted".

Where preventive maintenance fails in efficiency, predictive maintenance offers improvement. This method involves detecting and assesing material degradation by monitoring wear debris, noise levels, vibration amplitude, leakage/slippage severity, corrosion, pressure, flow, temperature, and rotational speeds of critical components. Commonly-known vibration monitoring provides many benefits; however, wear usually occurs well ahead of aberrant vibration signals in most rotating machinery. This and other predictive maintenance techniques provide early warnings of small amounts of damage before "catastrophic" failure occurs. But at this point, damage has already been done.

While effective to a degree, neither preventive nor predictive maintenance is geared to detect the most common & serious culprit of contamination. Proactive maintenance is specifically designed to extend the life of mechanical machinery by controlling contamination. Proactive maintenance prevents (1) making unnecessary repairs, (2) accommodating failure as routine and normal, and (3) crises failure maintenance. Therefore, the first logical step to proactive maintenance is the implementation of a strict contamination control program. It is a strategy that receives support from industry and educational institutions alike.:

* According to the bearings division of TRW, "contamination is the number one cause of bearing damage that leads to premature removal".

* Massachusetts Institute of Technology states that "six to seven percent of the Gross National Product ($240 billion) is required just to repair the damage caused by mechanical wear".

* According to Caterpillar, "dirt and contamination are by far the number one cause of hydraulic system failures".

THE STEPS TO CONTAMINATION CONTROL

Heat, moisture, air and particles literally rob fluids and lubricants of life. With rigid contamination control practices, these fluids and lubricants can last indefinitely which, in turn, prolongs the life of the machine's components and keeps machinery running at the highest level of efficiency. A basic contamination control program can be implemented in three simple steps :

1. Establish the target fluid cleanliness levels for each machine fluid system.

2. Select and install (or upgrade) filtration equipment and contaminant exclusion techniques to achieve target cleanliness levels.

3. Verify target cleanliness levels by monitoring fluid conditions at regular intervals.

CONTAMINANT MONITORING CRITICAL

Fluid contaminant monitoring is the most critical element to achieving the goal of extended machine life. Machine contaminant levels, as affected by ingression and filtration, are extremely dynamic. It is not unusual for levels to vary two or three orders of magnitude over a period of days or even hours. Contamination monitoring provides the earliest indication of a poor fluid-related condition and therefore provides essential feedback for successful contamination control.

Particle counts that exceed the predetermined target cleanliness level alert maintenance professionals to begin troubleshooting. Ideally, troubleshooting corrects a condition that would otherwise lead to a costly, catastrophic problem. When troubleshooting problems, maintenance personnel must ensure that the root cause, not the symptom, is treated. For example, changing the oil in a system with high contamination levels is a common practice that simply masks the problem. If the root cause is a failed seal, changing the oil removes the particulate contamination but does not correct the real problem. Within hours of the change, contamination levels return to the previous dangerous levels and continue to cause production problems. It is critical to treat the problem instead of treating the symptom. The troubleshooting process should be systematic. First, an on-site particle count must be verified to ensure accuracy. If the contamination level is accurate, the contamination must be analyzed to determine whether dirt or wear debris is the source of the increased particle count. If dirt is the problem, the system should be visually inspected for failed filters, tank breathers, or seals. If wear debris is the problem, an oil laboratory can analyze the contaminated fluid to determine the quality of the oil and identify the wear material. In typical machines, ferromagnetic particles can represent more than 70% of wear debris generation. Portable instruments that quickly check for the presence of contamination and wear debris are available. In addition, predictive maintenance equipment, such as thermal and vibration sensing instruments, can pinpoint problems. With the information from the various inspections and tests, maintenance personnel can make better-informed repair and replacement decisions.

SUCCESS STORIES IN CONTAMINATION CONTROL

Various industries have reported their successes while using a proactive approach to maintenance. For example :

* Kawasaki Steel implemented a contamination control program involving improved filtration and rigorous fluid cleanliness monitoring. Within a five year period, they achieved an almost unbelievable 96% reduction in hydraulic component failures and 80% reduction in hydraulic fluid consumption.

* The British Hydromechanics Research Association (BHRA) conducted a three-year study based on the carefully monitored field experience of 117 hydraulic machines evenly spread across eight categories (injection molding, machine tools, material handling, mobile/construction, marine, metal working, test stands, etc.). The results of the study showed a dramatic relationship between fluid contamination levels and service life. Improved system cleanliness achieved extended actual mean time between failures (MTBF) from 10 to 50 times, depending on cleanliness.

* International Paper Company reported nearly a 90% reduction in bearing failures in just six months after they implemented improved filtration and contamination control in their Pine Bluff, Arkansas, paper mill.

DIAGNETICS' DIGITAL CONTAM-ALERT FOR MONITORING CONTAMINATION

Fluid contaminant monitoring can be accomplished in the field or plant by extracting samples of fluid into bottles for lab analysis or by using portable instruments right at the machine. Recently, there has been a trend away from bottle sampling and lab analysis for routine contaminant monitoring due to the associated high costs, reduced accuracy, and time delay. In its place has been the use of portable monitors that receive fluids directly from machines for on-the-spot analysis.

One instrument sold by Diagnetics, called digital Contam-Alert (dCA), is battery operated and extremely lightweight. It consists of a sensor attached by cable to a hand-held computer. During a test, the sensor is placed momentarily on a special diagnostic port permanently installed on the machine. A small sample of fluid under pressure passes into the sensor and, after a minute or two, the particle count is displayed on the computer screen.

The unit can be used with a variety of different fluids, such as lube oils, hydraulic fluids, gear oils, and coolants. After each test, the handle on the sensor is depressed to expel the sample, making it immediately ready for reuse. Particle count data can be easily stored in the computer, tagged to machine I.D. the date, and user comments. Later, the data can be printed out with a portable printer or down-loaded to a desk-top personal computer. Use of the portable contaminant monitor provides easy in-plant or in-field proactive or predictive maintenance. Maintenance operators can simply walk from machine to machine checking fluid contaminant levels and comparing them to target baselines. Maintenance work orders can then be issued to correct out-of spec systems.

SUCCESS EXPERIENCED BY COMPANIES USING dCA

Many companies have reported success using digital Contam-Alert (dCA) as the primary tool for their proactive maintenance programs. For example :

<u>dCA Applied to Steam Turbine :</u>

Arcadian Trinidad Ammonia Ltd., an ammonia complex in Pt. Lisas, Trinidad, conducted a study on contamination control applied to the lube oil system of a steam turbine.The focus was to determine the impact of system cleanliness on machine health. The exercise was conducted over a three month period, with on-line particle counts conducted biweekly using dCA fitted with a 10-micron screen. Samples were drawn upstream of filters through special diagnostic test ports, in accordance with ISO Standard 4021. The program commenced June 17, 1993, and concluded September 2, 1993.

During sampling, a sharp increase in particle count was observed on July 13. Results of routine laboratory analysis conducted on a sample indicated that the system contained a substantial amount of free water (>10% by volume). The turbine on which these observations were made was driving a fresh water pump critical to plant operations, and could not be removed from service. Centrifuging was instituted on a temporary basis to maintain moisture content within allowable levels. Particle counts on samples taken on July 27 revealed a return to a satisfactory level. The contaminant monitoring program enabled plant personnel to :

* Identify sources of contamination and plan for correction; a problem that would otherwise have gone unnoticed until detected by the in-house vibration department.

* Extend the life of lubricant, filters and components and reduce component replacement costs.

* Reduce equipment downtime through implementation of early remedial measures.

* Peg oil analysis decisions to contaminant levels.

* Appreciate the value of contaminant monitoring as a proactive maintenance activity, which is able to detect system problems prior to the impact of its symptoms.

dCA Applied to Hydraulic Systems :-

ALUMAX of South Carolina is an aluminium mill with a multitude of hydraulic systems. The South Carolina plant opened in mid-1980. By 1983, ALUMAX was spending between US $ 11,000 and US $ 15,000 for hydraulic component replacement on two machines, not including labour or downtime.

The two systems on which ALUMAX focused were both systems that had variable volume piston pumps, along with several 3/4" and 1/2" solenoid-controlled conventional hydraulic valves, load holding valves, pressure reducing valves, and system relief valve. The actuators were differential area, double-acting hydraulic cylinders. Each system also contained 11 cylinders and two pumps. Filtration consisted of a 10-micron absolute "kidney loop" system.

Particle counts showed contamination in the hydraulic fluid in their systems. Cleaning the fluid with a portable filtration cart during system operation, then monitoring the system contamination levels using dCA and watching particle counts continue to increase, proved to ALUMAX that the OEM filtration was insufficient.

To correct the problem, return line filtration including two 3-micron absolutes and breather filters, was added to the reservoirs. The 10 micron filtration already in place was converted to 3-micron. After the improvements, the system began operating below their maximum allowable contamination level of 18/16/13, an SAE grade 4. Over a period of six years, ALUMAX saw a decrease in hydraulic component replacement cost between US $ 11,000 & US $ 15,000 per year to virtually zero dollars in 1989 (not including downtime or labour).

SUMMARY

Quality machine and fluid information forms a solid basis for a successful proactive maintenance program. Without a strong contamination control program, machinery vital to the production process could be silently moving toward failure. Particulates entering the system through external means build up in the fluid, slowly disabling internal components and causing a breakdown. Understanding and monitoring fluid conditions allows maintenance personnel to be progressive in fluid and component repair and replacement activities, thus preventing failures before breakdowns occur.