Issue Focus: Gearbox Lubrication Tips - 20/09/03

TIP #1

A bath system is not recommended for either low or high speeds in gearboxes. Under low speeds, a low-viscosity lubricant drips off the lower gear before it can be distributed to upper gears. In high speeds, the lubricant can be slung off.

TIP #2

When selecting a gear lubricant it is important to consider the load, speed, temperature, gear type and finish, and application method. In general, higher viscosity fluids are needed for higher loads and temperatures, lower speeds, rougher finishes and for worm gears. Extreme pressure additives should be used for heavy loads and moderate temperatures, but are not effective with yellow metals such as bronze or brass.

TIP #3

It is generally better to use an oil one grade too high in viscosity than too low in viscosity in gear applications because the more viscous oil

will provide more load-carrying ability and maintain a better film strength. A lighter oil may contribute to adhesive wear, low load-carrying ability and tooth damage. Ensure that the oil is not so viscous that it cannot be distributed properly through the gear case.

TIP #4

Refitting gearbox vents with breathers that restrict the ingestion of airborne dirt and debris will help control contamination from entering the unit. The reduced strain on the bearings in the gearbox due to the cleanliness improvement, reduces wear by an estimated 50 percent.

TIP #5

Overfilling a gearbox sump can be just as damaging as under-filling. Overfilling may cause air entrainment and foam, overheated oil and leakage due to overflow. Over time, oxidation may occur due to increased temperatures and exposure to air.

Controlling Gearbox Contamination

Martin Williamson

"Wear and tear" is an expression frequently used to describe the ageing of a mechanical system, though "use and abuse" might be more correct. Wear commonly occurs as a result of the contamination and degradation of the lubricant. The wear rate can be reduced quite dramatically as a result of

some basic measures to protect the gearbox from the wear, tear or abuse it generally receives.

Proactive maintenance is a well-documented and widely understood concept that has helped a number of sites achieve considerable benefits from their maintenance programs. This article addresses basic contamination control measures to help the reader achieve life extension, not just on the gear oil, but on the equipment itself.

A main point to consider is that gearboxes exist in a variety of formats, but all require lubrication because they all have moving components that transmit power through rotation. This means that contaminants can not only cause a breakdown in the health of the lubricant (and thus a failure in the lubricant's ability to perform efficiently), but will also interact with the moving surfaces to cause wear, leading to component failure. Adhesion, abrasion and corrosion of component surfaces will typically result from oil contamination as will poorly specified or unhealthy lubricants.

Here are two essential proactive aspects of lubrication management: The oil must be right for the job, and must be free of contaminants.

Consider this analogy: Assume you have just invited your manager to dinner next week as part of a career-enhancing plan. You buy a $5 bottle of red wine, open it, then stand the bottle in bright sunshine and allow it to breathe for a week before serving. What are your chances of a promotion? Likewise, the oil introduced to a gearbox should be of appropriate quality given the demands of the application, and should be stored properly before serving it to the gearbox.

Bear in mind that gearbox design and manufacture has changed significantly in recent years. New surface hardening techniques and metallurgy have enabled the manufacture of smaller gearboxes for a given horsepower rating. However, these changes have resulted in much more aggressive surface loading, and the thickness of super-hard material is often razor-thin. These harder surfaces are more resistant to particle-induced sliding wear, but they are highly susceptible to particle-induced rolling wear, which occurs at the pitch line of the geartooth where load is transferred.

When a particle is squeezed in the load zone, it can fatigue the hardened material, resulting in spall formation or dent, producing a proud area around the dent's crater. The plastic deformation that occurs where a surface is dented can dramatically alter the material's physical properties, making it more susceptible to wear and fatigue. Making matters worse, new gearbox designs tend to run hot, increasing the risk to the lubricant.
Due to these and other changes in gear design, it is more critical than ever to focus contamination control efforts on gearboxes. No longer can we limit contamination control to hydraulic systems, bearing systems and turbomachinery. Choosing to take charge of gearbox contamination control can result in substantially improved reliability record and reduced maintenance costs.

Identifying the Sources of Contamination

Briefly, contamination is any foreign body or matter that infiltrates the systems and causes harm to the unit, or substantially reduces its effectiveness or adversely affects operation. Common contaminants include hard particles, moisture, high temperature and aeration. Other examples include radiation, or process chemical or physical matter from the environment.

There are several easily identifiable ingression points on a gearbox, namely the seals and the breathers. Other less obvious sources of ingression are the result of maintenance activities, such as top-ups, complete drain and refill, or other intrusive servicing of the unit. Keep in mind that the rate at which contaminants enter the unit will depend to some extent on ambient conditions, the contaminant type and the conditions in which the machine will operate.

In wet conditions, the likelihood of moisture ingress significantly increases; however, the ingress of hard dust particulate from the environment is reduced accordingly. On the other hand, given a hot, dry and windy day, the risk of moisture ingress is minimized for outdoor equipment, but the risk of ingested hard atmospheric silica-based particulates is greatly increased. Depending on the nature of the organization, some contaminants may be unique, such as coal dust, iron ore dust, or process chemicals in a petrochemical or paper mill work environment. Another contributor to contamination is nearby activity. Consider the risk of cement dust around a construction site, and again the risk will be greater in windy or dry conditions.

Dealing with Sources of Contamination

The following is a bulleted list of items to guide efforts for achieving contamination control in gearboxes. It is always well-advised to address both contaminant exclusion and removal, paying special attention to exclusion. An old rule of thumb is that it costs 10 times as much to remove a particle than it does to exclude it. Experience proves this.

Review this list and talk with the OEM to see if some of the required changes can be engineered into the scope of new gearboxes. For existing gearboxes, the modifications will likely need to be done onsite. Call on experts to help devise the plan and execute the implementation if required. There are tricks to prioritizing one's efforts and finding the path of least resistance that can be learned only through experience.

Whether you choose to implement yourself or set up an ongoing improvement program, consider the following:

Seals - Standard lip seals are a low-cost item, but require frequent replacement. Their ability to seal against oil leakage and dirt/water ingress is poor by comparison to labyrinth seals.

Although labyrinth seals cost more initially, their superior performance will ensure minimal risk from water or dirt ingress, as well as minimizing lubricant loss and potential process/environmental problems. Typically, their lifecycle cost is lower. Of course, training the maintenance staff to avoid the use of high-pressure wash-down sprays directly on the seals is necessary. If this cannot be avoided, such as in food and drug related environments, a seal guard can prove beneficial.

Breathers - In many cases, older units still have an open tube (snorkel type) for breathing, although newer units now incorporate a vent plug. When it comes to stopping large bodies (rocks, rags and rodents) from falling into the gearbox, these serve their purpose, but they will not stop a destructive 10 µm particle from entering. That would be like a pool ball rolling through an open doorway.

In most cases, upgrading the vent to a proper contaminant-exclusion breather should minimize the ingestion of hard particles and moisture. There are several ways to achieve this. The first would be to fit a good quality breather, such as a 1 µm filter to remove as much of the airborne particulate as possible. In fact, a standard spin-on filter will perform effectively as a breather (Figure 3).

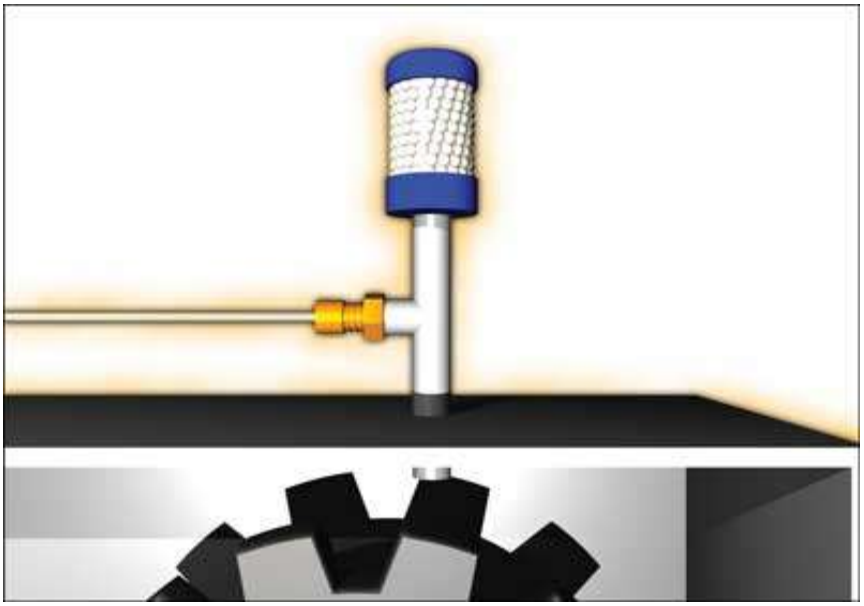

Figure 3 - Spin-On Filter/Breather

If in a moist environment, then the use of desiccating breathers is recommended. There are two schools of thought on desiccating breathers. Some believe that the exhausted air should be directed straight to the atmosphere, while others believe the warm, dry air can be used to regenerate the desiccant. However, on gearboxes (as compared to hydraulic reservoirs), there is little air flow through the breather. Their general purpose is to allow for changes in volume as a result of top-ups, leakage and temperature-related volume changes (usually during start-up and shutdown).

For applications where volume changes are minimal, such as in a gearbox, the bladder type (also known as expansion chamber) of breather is an option. This effectively seals the inside of the gearbox from the atmosphere. The bladder allows for expansion and contraction of the air within the casing as a result of temperature changes. These are especially ideal where high levels of particulate or moisture occur in the environment (Figure 4).

Breathers/Filters/Samplers - Where regular sampling or the use of a filter cart is needed, it is useful to combine the functions, particularly where cost and space constraints dictate. It is imperative to make sure the oil is delivered clean to the gearbox. This may mean dispensing through a filter cart (Figure 1) or using a one-shot type sealed lubricant container supplied at a certified level of cleanliness. The fill port must also be clean prior to use. Any type of protection against contamination that can be added to the fill area is beneficial. The use of quick-connect couplings is ideal. Like minimess sampling ports, they minimize the risk of ingested contamination.

Figure 5 - Breather/Filter/Sampler Combo - Mounts on Top of Gearcase in Place of Conventional Breather.

Portable Off-line Filtration - While some gear units may incorporate a small pump and perhaps even a filter, many gearbox lubricants are not filtered. Sometimes, it is not possible to make the necessary upgrades or modifications without lengthy downtime.

Filter carts can usually be adapted by replacing the fill and drain plugs with quick-connect fittings. Select filter carts for easy maneuverability and allow for a selection of filter ratings (including small amounts of water removal) within the design constraints of the pump on the unit. It is best to dedicate a cart to one oil type or family to avoid cross-contamination of fluids.

To select the right flow rate, etc., the differential pressure across the filter(s) must be within operational allowances, and selecting a lower flow rate pump is advised for higher viscosity gear oils. At least five to seven times the volume of the oil in the system should be passed through the filter cart to ensure adequate clean up. Be sure that all safety considerations have been covered to avoid deadheading of pumps or exploding filter canisters!

Permanent Off-line Filtration - On larger units, or particularly where large volumes of oil and/or high levels of cleanliness must be maintained, a permanent off-line circuit should be employed. An extra benefit of the permanent mount is that it can continue to operate while the gearbox is not in use, although the optimum filtering time is during the higher operating temperatures. It is often a good idea to incorporate a cooling system to reduce the oil temperature and increase the oil's life and improve its performance.

The choice between a portable unit and a permanent mount unit comes down to criticality of production (the need for reliability), safety and severity/penalty of failure. Also, the accessibility of the unit for periodic filtration should weigh in the decision. If these factors are important, then achieving a reasonable life extension within a limited budget is based on contamination improvement. Absolute levels of cleanliness should not be quoted as individual units within the same site; they may have differing needs imposing higher or lower cleanliness limits. However, it is safe to say

that in the majority of cases, there are areas for improvement from the typical ISO */23/20 often seen by the author. The stringent cleanliness levels required by complex hydraulics are not necessary with gearboxes unless circumstances are exceptional, but aiming at a cleanliness target of ISO */16/13 is reasonable. With improvements to that level, machine life extensions in excess of three times are realistic.

The cleanliness of units at the commissioning stage is crucial to ensuring successful infant reliability and increased life of the unit. It is not uncommon to find manufacturing debris (casting sand, machining swarf, etc.) present in a new gearbox. At least one OEM states that this is normal, and if the client wishes to have it removed, there is an extra charge. This is unacceptable, and as a client, vote with your order book. Unfortunately, reality sometimes means staying with the supplier.

At the very least, the client should ensure that when specifying new units, the best quality breather and seals are fitted as standard. Check that any openings in the casing, etc. are plugged and the shafts and gears are covered with a protective film of grease or oil which is thoroughly removed before use. Make use of the portable filter cart to flush the gearbox before it is turned. The best way to flush is to use a compatible low-viscosity base oil, or a low-viscosity variation of the service oil that can flush through the box ensuring that all the dead zones are cleaned and any debris dislodged is removed by the filter cart. If you are requesting the OEM to do this before delivery, ensure that he flushes in accordance with the appropriate standards and shows certification or proof of achieving required levels. While these additional specifications may add to the initial purchase cost, the savings incurred in the increased reliability and life of the unit can far outweigh the penalty.

The same stringent flushing techniques should be applied following the intrusive service of a gearbox. Whenever the machine is opened for repair, you can bet on a significant contaminant ingress. Flush the box before putting it back into service.

It is a new world for gearbox lubricant maintenance. New gearbox designs cannot operate reliably with contamination. This, combined with ever-increasing demand for equipment reliability makes contamination control a new and significant concern for gearbox maintenance. Be sure you are properly protected