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LUBRICATION MANAGEMENT FOR IMPROVED RELIABILITY - APPLICATIONS

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Lubrication practices within a plant have a direct effect on plant and equipment reliability. When a lubricant is working effectively in a machine with no chemical degradation and with limited contamination within it, wear will be reduced and equipment reliability will be improved. The key to reducing component wear and to increase equipment reliability is effective and clean average lubrication film thickness – in other words protecting and maintaining a good lubrication viscosity.

The discussion in the industrial maintenance world today is predominantly focused on plant and equipment reliability. The real meaning of equipment reliability is often hidden behind other terms like World Class Maintenance, Asset Efficiency, Proactive Maintenance, Predictive Maintenance, Lubrication Management, Lean Manufacturing, TPM and even 5S (Sorting, Straightening, Systematic cleaning, Standardizing, and Sustaining). However, irrespective of what companies choose to call it, they all have fundamentally the same objective.

"Equipment reliability is a maintenance strategy or culture which, when implemented successfully, will assist in reducing maintenance costs, improving equipment uptime and lowering the overall costs of production."

Many companies set out on the pathway to achieve the above conceptual definition(s) and invest in people and technologies as their defined processes require, however the lubrication component of the strategy, is more often than not, low on the appreciation scale and consequently their efforts do not always meet the expectations.

Our experience shows that companies at World Class or Best in Class levels, focus at great length on the management of their lubrication activities, because they understand the effect lubrication has on equipment life.

Figure 1. The key to increase equipment reliability is effective and clean average lubrication film thickness.

What is Lubrication Reliability?

All investigations conducted today on why bearings fail, will reveal the alarming fact that over 60 % of the damages are lubrication- related. The bearing is the rotating core of the machine and if we can reduce the lube-related failures we will directly improve the equipment reliability, not to mention the resulting reduction in bearing consumption.

Bearings and other rotating components need a good lube film thickness to separate the metal components and to reduce wear. However, generating a good film thickness is a chemically complex mechanism which is dependant on many factors, such as degradation of the lube, contamination in the lube, effective replenishment of the lube and no mixing of lubes.

So when the lubrication works in a *reliable way*, the equipment reliability will improve, meaning that a *Lubrication Reliability strategy* is all about ensuring that effective machine lubrication occurs within the machine resulting in reduced wear and failures.

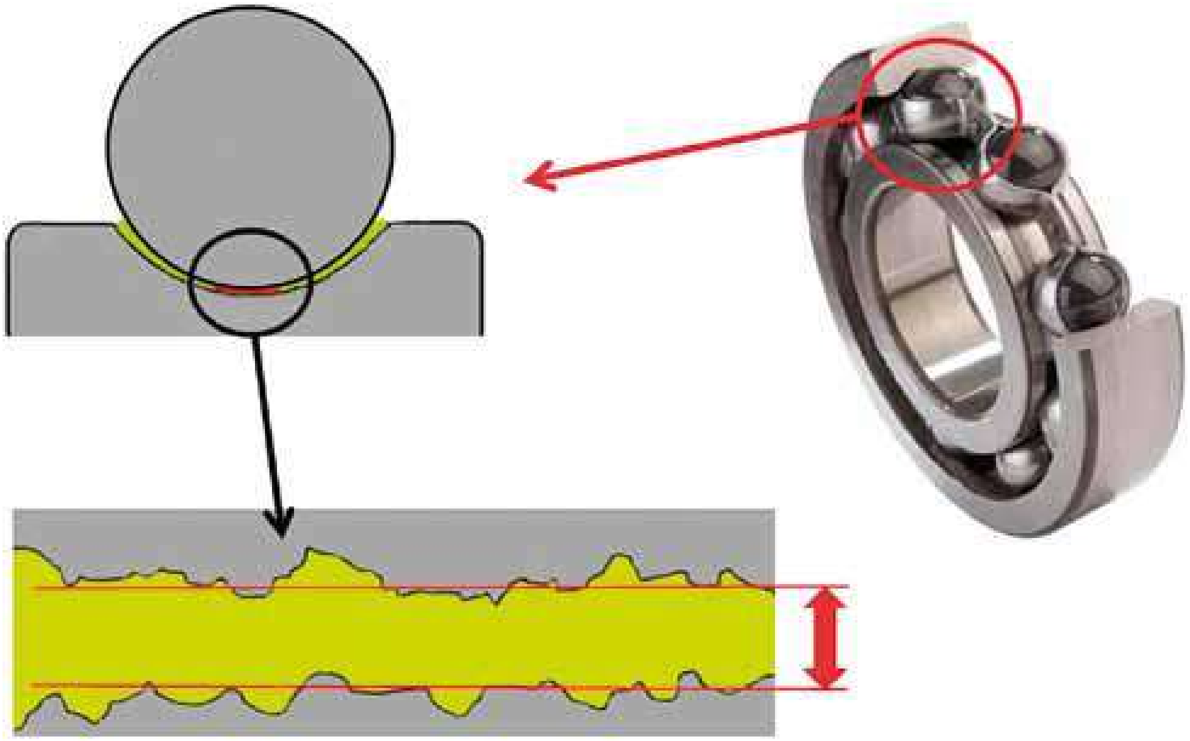

Figure 2. Lubrication film thickness is 1/20 of the thickness of human hair).

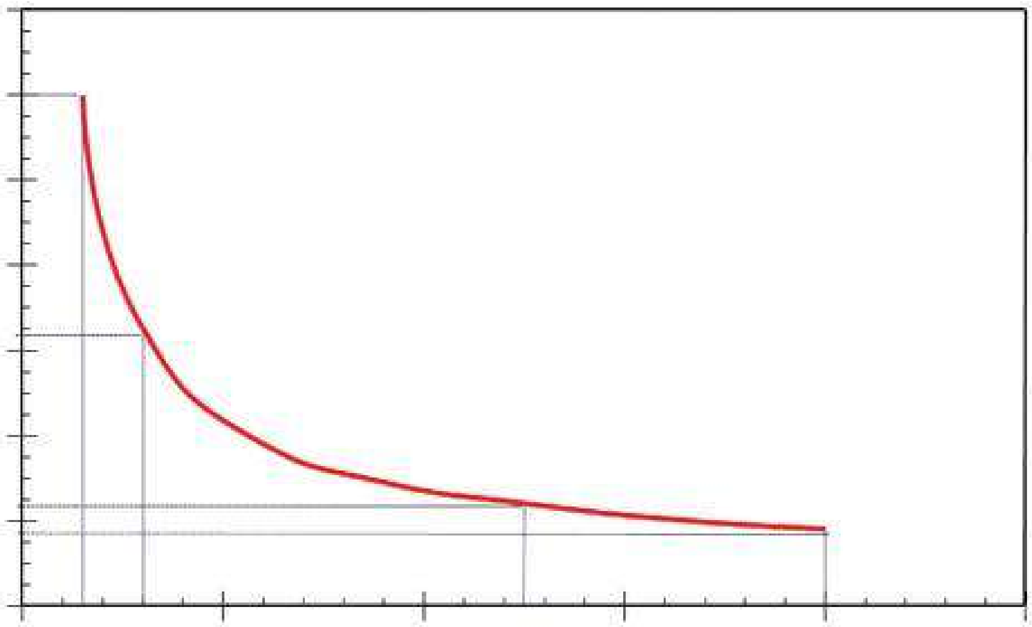

Figure 3. Filter ratings vs. cycles to fatigue failure. Ref Dr. D. P. MacPhearson of Westland Helicopters Ltd.

It is all about Lube Film!

Firstly let us talk a little about what causes wear and equipment breakdowns. SKF has stated that, *“bearings can have an infinite life when particles larger than the lubricant film are removed”*, meaning that removal of abrasive particles will prevent bearing wear.

In a bearing with a good average lubrication film thickness, the metal surfaces are separated. The average thickness of this separation or film is very small, about one twentieth of the thickness of a human hair (figure 2).

The analogy is that when a 50-micron particle of hard contaminate goes through the bearing, it is like driving your car over a 1 meter diameter boulder. When there are hard contaminants in the oil and they are greater in size than average lube film, then three-part abrasive wear starts to happen. This then leads to surface indentation and scratching, which is a process that can lead to bearing or component failure.

A good average lubrication film thickness in a machine or component is the result of a lubricant operating with an effective viscosity. Assuming that the right lubricant viscosity has been selected in the first case, then if the oil is kept clean (meaning that there is a very low level of abrasive particles in it and there is no degrading of the chemical composition of the oil), then the lubrication will do the job, which is to provide an average lubrication film thickness that will separate the metal components and eliminate or reduce wear.

Viscosity changes are the result of oil degradation, contamination or both. Oxidation is one of the main causes of a viscosity change as it will initially cause an increase of viscosity, and as the oxidation increases the viscosity will then begin to decrease to a dangerous level. The decrease of a lubricants viscosity is the most dangerous effect to any components reliability as it can lead to the breakup of the lubricating film generation process and increase the wear potential.

The objective of this article is not to understand the chemistry of all the factors that affect the lubricants ability to do its job, as that is a whole discussion of its own, but more about how to understand what we must do to manage or maintain a good operating lubrication viscosity. Below are five key points to consider in the efforts to use lubrication reliability as a strategy to improve equipment reliability:

- The lubricant film is what ensures the separation of metal surfaces, thereby preventing wear and reducing friction.
- When the oil is contaminated with hard particles greater in diameter than the average lube film thickness, then three part abrasive wear will occur, also leading to wear and increases in friction.
- Chemical changes of the lubricant will also affect the viscosity of the lubricant.
- There should be processes in place to ensure that a low level of contamination is present in the operating lubricant.
- There should be processes in place to know when chemical changes are happening to the lubricant in operation.

Understanding Oil Contamination

The number one problem with lubrication today is contamination; this can be particle contamination or chemical contamination or both. A lubrication reliability strategy consistently uses three words: *Cleanliness*, *Contamination* and *Control*, and when combined they are generally used as *cleanliness control* and contamination control. It is important to clarify the difference between the two distinctly different activities. They both need to be considered in the quest to reach a best practice standard.

Cleanliness control is the processes and tools to ensure that only clean lubricants are *added* to the equipment, whereas *Contamination Control* is the processes and tools to ensure that only clean lubricants are *operating* in the equipment.

Why the difference? If in lubrication management we spend a lot of time, effort and money to ensure that the lubricants operating in our equipment are kept very clean, then why would we add dirty oil to an already clean system as it makes our work even harder, not the mention more costly.

Particle Contamination

The effects of particle contamination on bearing life is supported by a research project conducted by Dr. MacPhearson who looked at the relationship between filter ratings and millions of bearing cycles to fatigue failure (figure 3). His research, and others conducted on the effect of contamination, conclude the same basic fact – the cleaner the lubricant the longer the machine life.

The International Organization for Standardization created the cleanliness code ISO 4406 to quantify particulate contamination levels per milliliter of fluid at three sizes: 4 micron, 6 micron and 14 micron, and it is this code that is used by most companies to set their targets for lubrication cleanliness. This ISO code is expressed in 3 numbers, for example 22/18/13, each number representing a contaminant level code for the correlating particle size.

Companies that are managing their lubrication contamination, have ISO 4406 targets for different applications and set targets accordingly depending on the criticality of the machine in their processes. Below are some examples of recommended target levels:

- Hydraulics 15/13/10
- Turbines 16/14/11
- Engines 17/15/12
- Gearboxes 18/16/13

Other companies can have overall target levels set for their entire plant. In any case the key is to have a target level and then to employ the actions to ensure that the target level is reached and maintained.

Organizations at Best Practice levels in managing their lubrication activities, understand that oil can be contaminated in the process from where it is received, at the store and when it is running in the machine. Below are some examples of how the lubricant can become contaminated along the way:

- Oil arrives on site. (possible ISO 18/16/13)
- If a drum is left open.
- Dirty stick to check the drum level.
- Oil dispensed with dirty containers.
- Dirty hoses and funnels used.
- Machine running without air breathers.
- Wear debris is being generated in the machine and oil is not filtered. (possible ISO 24/22/11)

The chart in figure 4 is an example of the reduction of the number of particles in a system when moved from an ISO code of 24/22/19 to a best practice of 16/14/11. The number of particles in the oil is 250 times less when the best practice level is achieved.

Additionally, considering that the average lubrication film thickness is less than 4 micron, it is easy to appreciate how the component wear in the system can occur. The bottom line is that we need to ensure that only clean oil is added into the machine and is operating in it.

ISO Code	4 µm More than	Up to & incl.	6 µm More than	Up to & incl.	14 µm More than	up to & incl.
24/22/19	80,000	160,000	20,000	40,000	2,500	5,000
18/16/13	1,300	2,500	320	640	80	160
16/14/11	320	640	80	160	10	20

250 times less contaminants from 24/22/19 to 14/14/11

Figure 4. Number of particles in oil.

Managing Particle Contamination

There are 5 steps that need to be considered when managing the oil cleanliness and contamination levels:

- Receipt of new oil.
- Storage and conditioning of new oil.
- Dispensing of the oil to the machines.
- Stopping contaminants entering the machine.
- Removing contaminants generated in the machine from wear.

1. Receiving New Oil

In step 1 it is important to remember that new oil is not necessarily as clean as we would like, and if we are serious about our cleanliness standards we should make sure it is conditioned before use to the acceptable standards. If we store oil before use, it needs to be stored in a dry and clean location. The drums should be preferably stored horizontally with the two entrances at 9 and 3 o'clock and to ensure that they are not kept too long in storage and that the “first in first out” process is employed.

2. Storage and Conditioning

Best practice lube storage is that all new oil is not only kept clean and dry, but that the oil is also filtered before it enters the machine. Modern systems filter the oil in two ways, over the storage containers and when transferring the oil to the dispensing container.

3. Dispensing of the oil to the machine.

Step 3 involves using dispensing containers that are not only fully sealed, but also dedicated for each type of oil (figure 5). In addition, to stop contaminants entering the oil, we also need to ensure that the right lube gets into the right machine, the standard practice is to use a colour-coded system - one colour for one type of oil. The storage facility, the dispensing containers and the fill points all need to be labelled.

Figure 5. Dedicated dispensing containers are required for each type of oil.

Figure 6. Protection of oil reservoirs with Air Breathers.

4. Stopping Contaminants Entering the Machine.

All oil reservoirs need to breathe unless they are protected. This breathing process is a source of airborne contaminants entering the system and the fitting of Air Breathers on the systems is required to prevent water, dust and dirt from entering the system (figure 6).

5. Removing Contaminants Generated in the Machine.

The fifth step of the process is to filter the system in order to remove any contaminants generated from within, such as wear debris.

Managing Chemical Contamination

As mentioned earlier the lubricating oil can also be contaminated chemically, for example water entering the system or oxidation occurring within the process. These chemical contaminants will also affect the average lubrication film thickness and any well-managed lubrication activity will use an oil analysis process to monitor the development of them.

Return on Investment (ROI)

A well-structured lubrication strategy will require some investments. The costs are generally associated with the following activities:

- Dedicated lubrication management software
- A remodelled or a new lube storage area
- Oil dispensing systems
- Air breathers
- Filtering units
- Labelling discipline
- Oil analysis tests
- Lubrication training for dedicated staff.

Depending on how advanced a company is with their existing lubrication strategy and their size, these costs can be anywhere from $20,000.00 to $150,000.00. A lot of money, however it is an investment that will quickly pay itself back by:

- The elimination of one failed electric motor, due to lack of lubrication.
- Doubling the life of a number of gearboxes due to cleaner oil.
- Reduction in the bearing costs, annually by a conservative 30 %
- Doubling the life of all hydraulic systems and pumps.

Conclusion

Lubrication practices within a plant have a direct effect on plant and equipment reliability. When the lubrication is working effectively, wear will be reduced and equipment reliability will be improved. A Lubrication Reliability strategy focuses on all parameters that protect the average lubrication film thickness thereby reducing component wear and increasing equipment reliability.

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