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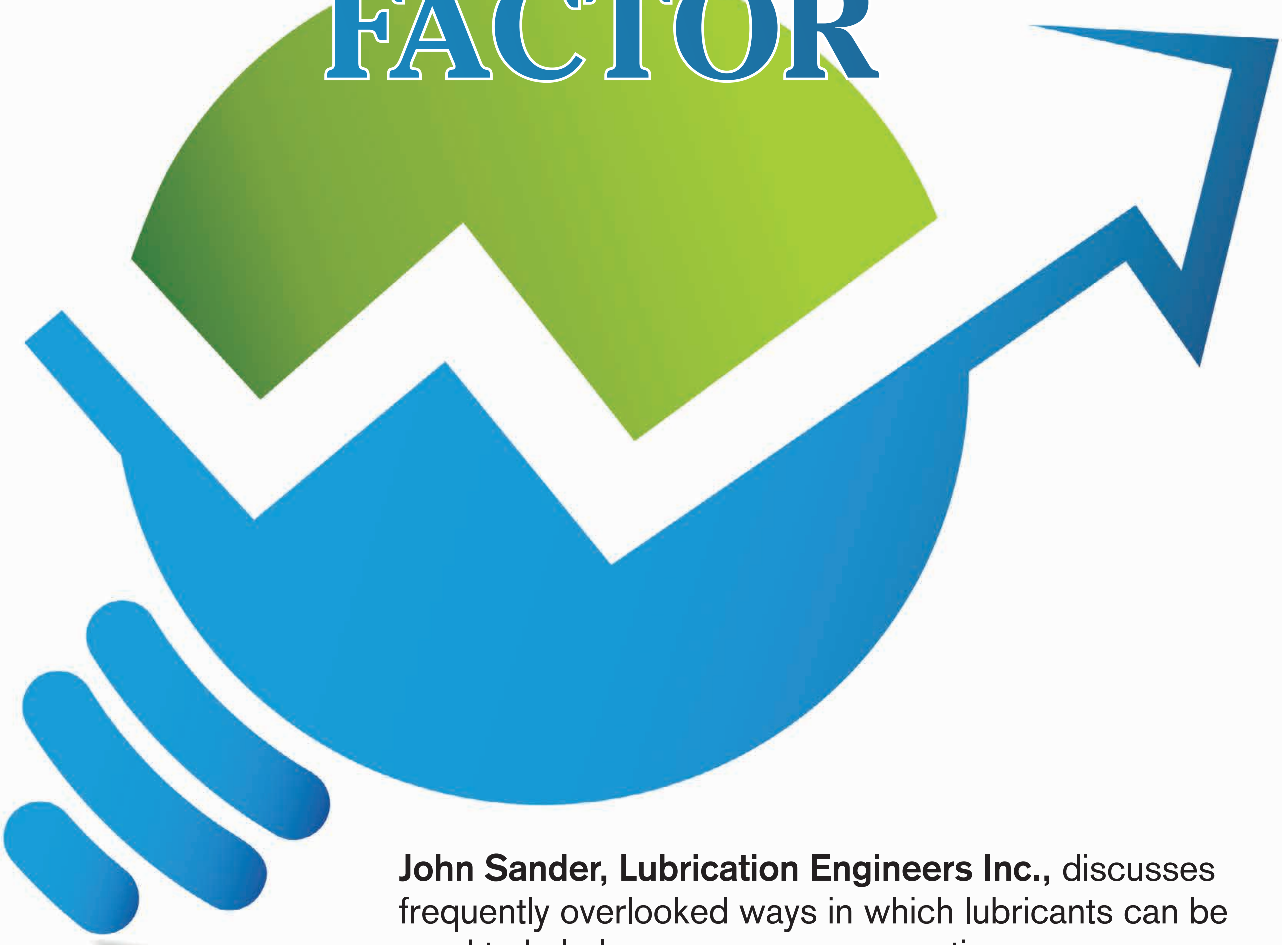
SAVING ENERGY: THE LUBRICATION FACTOR



John Sander, Lubrication Engineers Inc., discusses frequently overlooked ways in which lubricants can be used to help lower energy consumption.

It is a simple fact: better lubrication can lead to dramatic energy savings and an improved bottom line. This ought to interest any plant manager who is looking for ways to reduce operating costs and is especially significant at a time when stricter government regulations are in direct contradiction to reducing costs. Lubrication reliability is the solution. This article will describe how manufacturing plants can use lubrication reliability best practices to reduce their energy consumption, emissions and operating costs – all at the same time.

Introduction

Energy usage is a cornerstone of today's society. Economic development and improved standards of living both rely upon the availability of energy. According to *The Outlook for Energy: A View to 2030* by Exxon Mobil, energy usage per person varies dramatically around the world but equates to an average of 200 000 Btu/day, which is 15 billion Btu/sec.[1] This same study points out that each person has direct and indirect energy demands. Direct demand of energy is the energy that drives their personal vehicles and operates their homes, while indirect demand is the energy that heats and cools buildings, generates power, produces goods and services, and provides mass transportation of goods and people.

As less developed parts of the world modernise, their needs for energy will grow, resulting in increased costs for fuel worldwide. Along with this, many of the world's governments are passing stricter laws regulating clean air and water, toxic waste, pesticides, endangered species and more. These factors – combined with a struggling economy – result in a challenge for plant operations managers, which is to reduce operating costs. Often, this means doing more with less.

One way to reduce operating costs is to reduce energy consumption. Upgrading plant equipment to take advantage of newer, more energy-efficient technologies can reduce energy costs. Unfortunately, in a challenging economic environment, capital may not be available for plant upgrades. Simple changes in habits can also create considerable savings. One such change is improving the lubrication reliability programme. According to Peter Thorpe, Product Application Specialist at Shell, South Africa: "from a cost point of view alone, lubricant costs are negligible when compared to energy costs, even before the production efficiencies of high-performance lubricants are factored in."[2]

Electric utility bills generally dwarf maintenance and lubricant costs. All three are part of any manufacturing operation. So, while controlling or reducing maintenance and lubricant costs is important, reducing electric utility usage is critical. This paper will show that tremendous opportunities exist to use an improved lubrication reliability programme to decrease plant energy costs, thereby increasing profitability.

Energy for work

During conversions from one form of energy to another, some useable energy is lost. These energy losses can be extremely costly to society. The science of physics reveals that lubrication can play a role in reducing energy losses by reducing friction.

Society uses many automated tools to perform everyday activities – often called work. These tools frequently include many moving parts to accomplish the chore they are designed to perform. It turns out that work and kinetic energy – also called the energy of motion – are directly related. In 1687, Sir Isaac Newton published his laws of motion in *Principia Mathematica*. With these laws, Newton determined that the mathematical expression for kinetic energy (K) is:

a) $K = 1/2\, mv^2$

- m = mass.
- v = velocity at which the mass is moved.

So, it can be stated that it takes energy to move an object.

The laws of physics also state that work is the force required to move an object a certain distance as shown in equation (b). Work is also equal to the change in kinetic energy, indicated in equation (c).

Table 1. Lubricant types

Automotive (transportation)	Industrial (factories)
Heavy-duty diesel engine oils	Compressors
Passenger	Bearings
Automatic transmission fluids	Gearboxes
Aviation engine oils	Hydraulics
Mobile hydraulic	Turbines
Differential fluids	Chains/wire ropes
Torque fluids	Slideways
Chassis lubricants (grease)	Grease

b) $W = F\Delta x$

- F = force.
- Δx = change in position.

c) $W = \Delta K$

It turns out that friction is a force that exists in two forms: static friction (F_s) and kinetic friction (F_k). Friction is represented mathematically by the following two equations:

d) $F_s = \mu sN$ and $F_k = \mu_k N$

- μ_s = static coefficient of friction.
- μ_k = kinetic coefficients of friction.
- N = a force normal to the moving surfaces.

The coefficient of friction is a unit-less number that varies depending upon the composition of materials from which the moving surfaces are made. Obviously, the higher the coefficient of friction is, the higher the friction force.

Finally, the equation that describes the total change of kinetic energy (E_T) required in a moving system is the following:

e) $E_T = W_m + W_F$

- W_m = work to move the machine.
- W_F = work required to overcome friction.

So, physics shows that reduced friction would result in less energy needed to complete the desired work. Placed between two moving surfaces, a lubricant decreases the coefficient of friction. Naturally, this would also mean the more a lubricant decreases friction, the less energy the lubricated machine consumes.

Lubricant formulation basics

It has been said that 'oil's oil … just pour it in,' but this statement is far from the truth. Simply described, a lubricant is composed of a base fluid and additives. However, many lubricant suppliers formulate their lubricants according to unique recipes intended for specific purposes. Table 1 is a primer on the basic types of lubricants and the specific ingredient-driven categories.

Each of the lubricant types in Table 1 is usually broken down into narrower descriptions based upon the product formulation chemistry. Table 2 lists the categories and the additive types that dictate the categorical description. These descriptions are extremely simplified, as there are various base fluid types and even more additive types. Each formula category has its strengths and weaknesses and should be chosen based upon the needs of the application type.

It becomes obvious that lubricant formulations can be rather complex. When searching for the best lubricant to minimise energy loss due to friction, it is often a case of 'you get what you pay for.' In other words, an inexpensively priced lubricant does not necessarily provide maximum lubrication performance. As such, it may require a higher amount of energy consumption, sometimes at higher costs, than with a more expensive, better-performing lubricant. However, just buying an expensive lubricant does not ensure maximum lubricant performance and energy savings. The lubricant must be the right one for the application and must be properly maintained in order

Table 2. Lubricant categories by ingredient

Category	Ingredients described
Mineral oil	Base fluid derived from refined crude oil
Synthetic	Synthesised base fluids, such as PAO, esters, PIB, PAG and more
R&O (rust & oxidation)	Contains rust and oxidation inhibition additives
AW (anti-wear)	Contains wear-reducing additives
EP (extreme pressure)	Contains extreme pressure wear reducing additives
Multigrade	Contains viscosity-improving additives
DI (detergent inhibitor)	Contains detergent, dispersant, oxidation, wear, anti-corrosion additives
Others	Defoamants, emulsifiers, demulsifiers, pour point depressants, thickeners

for it to provide maximum performance. This means proper storage and handling, filtration, oil analysis, training and more.

All electro-mechanical equipment requires periodic maintenance to operate at peak efficiency and minimise unscheduled downtime. Inadequate maintenance can increase energy consumption. It also can lead to high operating temperatures, poor moisture control, excessive contamination and unsafe working environments. Depending on the equipment, maintenance may include the addition or replacement of filters and fluids, inspections, adjustments and repairs.[4]

So, how does the end-user know what to do? The answer is to find a lubrication partner that can help develop a comprehensive lubrication reliability programmme that includes lubricant selection, protection and maintenance. This partner could be a consultant, but it could also be a lubricant manufacturer that offers customised, comprehensive solutions, including lubricants and all of the related lubrication reliability products.

Lubricants and energy savings

It is possible to measure energy savings in a variety of ways, including production output, temperature changes or electrical reduction – all mentioned below. Another measurement is fuel consumption.

Production output

When equipment is used to perform work, it is possible to evaluate the equipment's energy efficiency by recording its production output. For example, if a machine is capable of producing a certain number of parts in a given amount of time and the lubricant is changed, resulting in a higher volume of parts being produced in the same amount of time, then the machine has become more energy efficient. One must be careful when using this technique to ensure that nothing changes in the process except the lubricant. This can be overcome by using a larger number of test units or evaluating productivity over a longer amount of time.

Temperature changes

Monitoring temperature changes is another way to optimise lubrication programme performance. Increased friction in a piece of moving equipment results in higher operating temperatures. Friction is a result of metal-to-metal contact that occurs between two opposing surfaces moving relative to one another. Even between highly machined surfaces, under microscopic view, asperity contact occurs.

The greater the amount of contact, the greater the amount of friction. As a result, more energy is required to move the surfaces relative to one another. This friction results in higher electrical power costs. Lubricants can reduce that friction. Therefore when friction is reduced, less electricity is required to drive a gearbox, compressor, pump or other pieces of equipment.

Sometimes, the bulk oil temperature is monitored in a piece of operating equipment. Another technique for evaluating lubrication performance is thermography, which involves using infrared detection equipment to look for 'hot spots' on a piece of equipment that could result from insufficient lubrication, improper lubricant selection or faulty operating parts. In any of these cases, higher temperatures result in wasted energy. It is important, however, to account for ambient environmental temperatures when performing this type of energy efficiency study. Obviously, a piece of equipment will run hotter on hot days than on cold days.

Conclusion

Today, there are various reasons to reduce energy consumption, such as conserving natural resources, reducing emissions and improving profitability. Governments and corporate management alike are looking for ways to reduce energy consumption.

Indirect energy use, more commonly called industrial use, is greater in all regions of the world than direct or personal use. That makes industry the largest consumer of energy and, therefore, the greatest source of potential reductions. Energy use can be measured through production output, temperature changes and electrical consumption. It is possible to make dramatic gains in energy efficiency by reducing friction, and one of the best ways to do that is to employ good lubrication practices, including the use of high-performance lubricants and the adoption of lubrication reliability best practices. The key to success is finding a lubricant company that not only can provide the right high-performance lubricants for the applications but can also recommend reliability solutions that will further reduce friction and maximise the efficiency of equipment. WC

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