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Energy Efficient Industrial Gear Lubricants

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

Global energy demand is predicted to be about 30 percent higher in 2040 compared to 2010 (1). Energy demand growth will slow as economies mature, population growth moderates and efficiency gains accelerate. This paper will focus on the third factor: energy efficiency. The industrial sector consumes almost 48% of global energy, with the remainder being used for residential/commercial and transportation. Clearly, improvements in energy efficiency in the industrial setting can have a major impact on overall global energy use and resultant CO₂ emissions.

There are multiple sources of lubricant-related energy loss in industrial equipment in general, and gearboxes in particular. These include frictional losses due to metal-to-metal contact, frictional traction losses under elasto-hydrodynamic lubrication conditions and windage/churning losses in the bulk oil. All three of these factors can be improved by using a properly formulated lubricant, with carefully selected base oils and additives to improve efficiency.

ExxonMobil has developed a series of industrial lubricants that can reduce energy usage by up to 4% relative to conventional lubricants. These savings have been documented in both carefully controlled laboratory testing and in extensive evaluations in actual industrial equipment in the field. Experiments to measure lubricant-related energy efficiency benefits are inherently challenging. Valid determinations of these benefits require precise measurements and controls, meticulous attention to detail and appropriate statistical analysis. In addition to the energy efficiency benefits, these oils can reduce equipment operating temperatures, resulting in increased component and lubricant life. This leads to longer oil drain intervals, and less used oil disposal.

ExxonMobil defines sustainability as having three components: social development, economic growth and environmental protection. In addition to discussing all of the points above, this paper will also describe how the new energy efficient lubricants contribute to each of these sustainability attributes.

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World energy use [1]

Global energy demand is predicted to be about 30 percent higher in 2040 compared to 2010, as economic output more than doubles and prosperity expands across a world whose population will grow to nearly 9 billion people. The use of energy has propelled the world from earliest civilizations, through the industrial revolution, to the current technology enabled world. It allows us to heat and cool our homes, travel to and from work, and utilize the multitude of manufactured goods we rely on.

Energy demand growth will slow as economies mature and population growth moderates. Overall, countries belonging to the Organization for Economic Cooperation and Development (OECD [2]) will see energy use remain essentially flat through 2040, whereas non-OECD countries will have energy demand grow by close to 60% (Figure 1). Demand growth will also slow as energy efficiency gains accelerate.

This paper will focus on increasing energy efficiency. The industrial sector consumes almost 48% of global energy, with the remainder being used for residential/commercial and transportation. This translates to 193 Quadrillion BTUs¹⁾ for industrial use out of a total of 406 Quadrillion BTUs in 2010. These amounts grow to 251 Quadrillion BTUs out of 535 Quadrillion BTUs in 2040 (Figure 2).

Sustainability

There are multiple definitions of sustainability available [3] [4]. Exxon Mobil Corporation defines “Sustainability” as balancing economic growth, social development and environmental protection (Figure 3 and [5]), so that future generations are not compromised by actions taken today.

This sustainability platform reflects ExxonMobil’s six corporate citizenship focus areas – protecting health and safety, managing climate change risks, respecting human rights and security concerns, promoting economic development, ensuring industry leading corporate governance, and reducing environmental impacts.

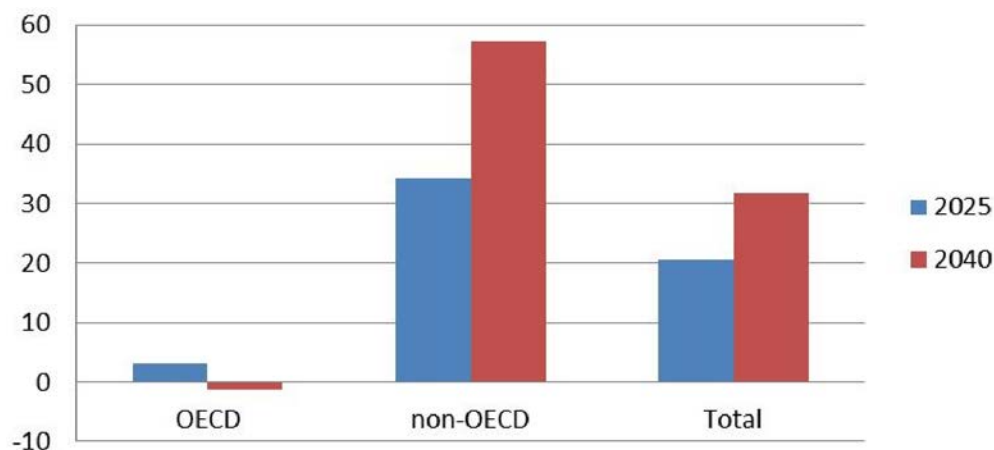


Figure 1. Percent increase in energy demand (vs. 2010)

¹⁾ BTU is the amount of energy required to heat 1 pound of pure liquid water 1°F. It is a common unit of energy used in the United States.

Advanced synthetic lubricants can address several of these areas of interest (Figure 4). For example, oils that extend oil drain intervals can contribute to health and safety by reducing the amount of interaction between humans and the machines. Longer oil life can also help reduce waste and transportation related energy use. The choice of proper lubricant can also help extend equipment life. This gives advantages in enhanced reliability and equipment availability leading to increased return on capital.

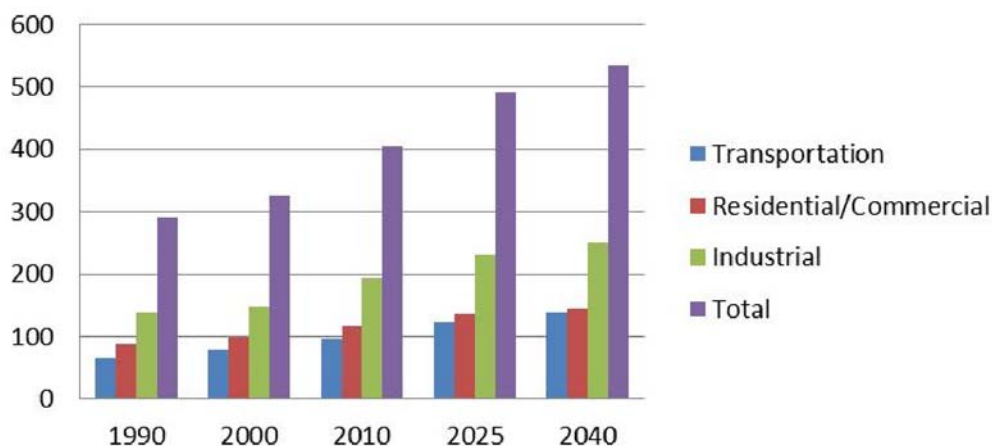


Figure 2. Projected energy use by sector (quadrillion BTU)

- Sustainability means balancing:
 - Social development
 - Economic growth
 - Environmental protection
- Ensures that future generations are not compromised by actions taken today



Figure 3. Sustainability — What is it?



Figure 4. Lubricants help drive productivity, sustainably

One of the key sustainability areas is to reduce environmental impact. One way to do this, and the focus of the rest of this paper, is by using advanced lubricants that can improve energy efficiency of the equipment they lubricate.

Sources of energy loss in industrial equipment

There are multiple sources of lubricant-related energy loss in industrial equipment in general, and gearboxes in particular (Figure 5). The causes of efficiency loss in gearboxes generally fall into two categories, those which are largely speed dependent and those which are largely load dependent [6]. There is the possibility to improve efficiency through hardware modifications [7] [8] [9], but this paper will focus on lubricant effects.

These lubricant related causes include windage/churning losses in the bulk oil, frictional losses due to metal-to-metal contact, and frictional traction losses under elasto-hydrodynamic lubrication conditions. All three of these factors can be improved by using a properly formulated lubricant, with carefully selected base oils and additives to improve efficiency.

Windage/churning losses can be minimized by using the correct viscosity lubricant for the equipment. The lubricant viscosity should be chosen to be able to keep the metal surfaces separated under a variety of conditions. The viscosity index (VI) of the lubricant is also critical, as higher VI oils will provide larger film thicknesses at higher temperatures.

In industrial equipment, the mechanical energy lost to friction typically represents only a small fraction of all of the energy that is transmitted but it can still have a significant value to a customer as the amounts of energy transmitted can be very large. In addition, the frictional energy is converted to heat, and the consequent temperature rise can have adverse effects, such as reduced oxidation life or reduced hydrodynamic or EHL protection through reduced viscosity.

Frictional losses can occur under all three lubrication regimes: hydrodynamic, elasto-hydrodynamic (EHL) and most significantly under boundary lubrication, where metal surfaces are actually in contact.²⁾

Hydrodynamic lubrication exists in systems where the contact occurs over a relatively large area (Figure 6). Bearings operating under hydrodynamic conditions can be found in a large number of applications:

- In industrial applications, both journal and thrust bearings can be found in a wide variety of configurations and sizes.
- In automobile engines, journal bearings are used to support the crankshaft and at both ends of the piston connecting rod.

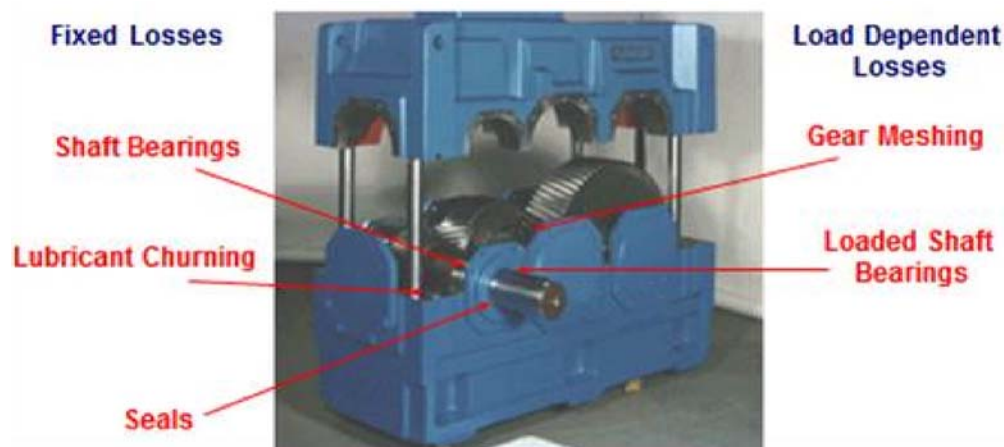


Figure 5. Source of energy loss in a gearbox

²⁾ See AGMA 925-A03 for more detailed review.