State of Pennsylvania

Energy Efficiency

Technical Reference Manual

Energy Efficient Industrial Lubricants: Reducing Energy Consumption with Industrial Lubricants

New Measure

Docket - M-2019-3006867

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12/14/2020

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Table 1 Work Paper Revision History

#	MM/DD/YY	Author, Company	Summary of Changes
1	12/14/2020	Justin Young, Eric Eriksen ExxonMobil	New Measure

1 Overview

The energy efficienct industrial lubricant is a measure based on an existing study within the Wisconsin Focus on Energy Technical Reference Manual and numerous academic and independent engineering studies. This measure was measured and verified in 2017 through the Focus on Energy Emerging Technologies Program. This measure is presented with an algorithm for savings calculation as well as a table of deemed savings values for common applications. This measure is expected to consistently deliver energy efficiency during all climate zones and seasons in Pennsylvania and for equipment located both indoors and outdoors.

Total manufacturing output in Pennsylvania in 2018 contributed $95 billion in gross state product (12%) from 12,262 manufacturers. Many of these manufacturers within Pennsylvania have made energy efficiency a corporate priority (e.g. Kiewit, Alcoa, Berry Plastics, etc). The plastics manufacturing sector alone **in Pennsylvania has the potential to save 9,990 MW-Hr per year** from a change to energy efficient hydraulic oils (at 3.3% energy reduction)[A]

In addition to manufacturing operations which consume notable quantities of energy, the mobile off-road fluid power market comprises construction, agriculture, material handling, oil and gas, and mining sectors. Combined, these markets consume up to 1.8 quads of energy per year in the United States, corresponding to approximately 6.5% of the total energy consumed in the transportation sector in 2017. [1] There is strong motivation within the hydraulic fluid industry to improve efficiency, productivity, performance, uptime/availability, life cycle costs, maintenance costs, and environment & safety compliance.[1]

Manufacturers who use electric-motor-driven hydraulic systems and electric-motor-driven gear systems can reduce energy consumption by a minimum of 3.3%[2].

Some manufacturers of industrial lubricants have committed to providing products and services that help deliver tangible performance and sustainability related benefits — as well as material economic advantages — to manufacturers. As a result, they have developed an extensive range of high-performance lubricants that can help increase equipment operating efficiency. At the same time, these lubricants can help contribute to reduced energy and resource use, lower emissions, and cost savings for industrial equipment.

The energy efficient industrial lubricants must meet the rigorous criteria for energy efficiency. Statistically valid data must be available to substantiate the energy efficiency claim and demonstrate a statistically significant decrease in energy consumption or increase in efficiency when compared with commercially available products designed and intended for the same application.

2 New Measure Characterizations

DESCRIPTION

Industrial hydraulic systems use hydraulic oil to transfer input energy to output power. Hydraulic oils also protect critical components from premature wear. Energy efficient hydraulic oil lubricants meet these requirements and provide reduced energy consumption. Energy efficient hydraulic oils have a lower coefficient of friction which reduces the friction between two moving parts (rotating pump equipment and hydraulic oil). This lower coefficient of friction reduces the energy required to yield output power. Second, these oils have a high viscosity index which reduces the effect temperature has on the viscosity of the hydraulic oil. The high viscosity index allows constant viscosity over a range of operating temperatures which optimizes volumetric and mechanical efficiency at the pumps rated output. Additionally, energy efficient hydraulic oils reduce the operating temperature of the hydraulic system.

Manufacturers who use electric-motor-driven hydraulic systems can reduce energy consumption by a minimum of 3.3%. This measure was developed to be applicable to the following program types: NC, RF, and Time of Sale – New Equipment.

If applied to other program types, the measure should be verified as a custom measure.

DEFINITION OF EFFICIENT EQUIPMENT

This is applicable for small, medium, and large manufacturers in all climate zones using electric motors to power their hydraulic system both inside and/or outside conditioned areas; or for all hydraulic systems on mobile equipment in all climate zones on Pennsylvania.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is defined as hydraulic systems using non-energy efficient industrial hydraulic oils which provides no energy efficiency benefits. In the formula below, the baseline equipment is where, η = zero.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years. The energy efficiency is a result of reducing friction in the operating equipment. The useful life of the lubricant is deemed to be 10 years when properly maintained.

The ability to reduce energy consumption (energy efficiency) is an inherent characteristic in the oil which does not deplete over time. As long as the energy efficient oil is in use, it will provide energy efficiency.

DEEMED MEASURE COST

Incremental costs equal the price difference between an energy-efficient hydraulic oil and a standard hydraulic oil which will vary across the state of Pennsylvania. Example costs are demonstrated in the appendix.

[3] Public Service Commission of Wisconsin, "Evaluation – Business Program: Measure Life Study," Focus on Energy (2009): page 1-4, Table 1-2 Recommended Measure Life by WISeerts Group Description for Building Shell Equip or Tech measure type, accessed December 3, 2019, https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

LOADSHAPE

N/A

COINCIDENCE FACTOR

No coincidence factor though it is noted that reduced consumption for equipment will reduce the overall baseload power demand, especially if a construction operation or manufacturing operation demand more utility power in summer weather (e.g. construction ground work, rubber manufacturing, etc).

Algorithm

CALCULATION OF ENERGY SAVINGS

Savings are calculated based on a reduced coefficient of friction and the shear-stable high viscosity index value associated with energy-efficient hydraulic oils in hydraulic systems. The algorithm below for Energy Savings, ΔE, is modeled after the Focus on Energy Emerging Technology Program M&V study.

ELECTRIC ENERGY SAVINGS

$$\Delta E = Motor\,HP * \left[\frac{0.746\,kW}{HP}\right] * \left[\frac{\%\,motor\,loaded}{motor\,efficiency}\right] * \left[\frac{Hours\,of\,Operation}{year}\right] * \eta$$

Where:

ΔE = Reduced energy in kWh/Year.

Motor HP = Rated power consumption of electric motor, summed when pumps are in series.

% motor loading (Load) = Output power as a % of rated power and is calculated as follows:

$$\%\,motor\,loading = 100\% * \left[\frac{Measured\,three\,phase\,power\,in\,kW}{Input\,power\,at\,full\,rated\,load\,in\,kW}\right]$$

For example calculations, load% is assumed to be 75%[9]. See chart in reference 9.

Motor efficiency = 92% estimated for motors in the size range typically used.[5, 8, 9] See references;

see chart in reference 9.

Hours of Operation per year = Number of operating hours per year.

η = Efficiency, minimum 3.3%.[2, 10]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$$\Delta E = Motor\,HP * \left[\frac{0.746\ kW}{HP}\right] * \left[\frac{\%\ Motor\ loaded}{motor\ efficiency}\right] * \left[\frac{Hours\ of\ Operation}{year}\right] * \eta$$

Where:

ΔE = Reduced energy in Fuel Consumed/Year. To calculate the quantity of diesel fuel reduced in hydraulic construction equipment (i.e. excavators, etc), multiply the quantity of fuel consumed annually by η. This efficiency translates to the reduced quantity of fuel consumption. [6, 12]

Motor HP = Rated power consumption of electric motor, summed when pumps are in series.

% motor loading (Load) = Output power as a % of rated power and is calculated as follows:

$$\%\ motor\ loading = 100\% * \left[\frac{Measured\ three\ phase\ power\ in\ kW}{Input\ power\ at\ full\ rated\ load\ in\ kW}\right]$$

For example calculations, load% is assumed to be 75%[9]. See chart in reference 9.

Motor efficiency = 92% estimated for motors in the size range typically used. [5, 8, 9] See references; see chart in reference 9.

Hours of Operation per year = Number of operating hours per year.

η = Efficiency, minimum 3.3%.[2, 11, 12]

WATER AND OTHER NON-ENERGY IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Example O&M Cost Adjustment Calculation

$$\Delta E = Motor\,HP * \left[\frac{0.746\ kW}{HP}\right] * \left[\frac{\%\ motor\ loaded}{motor\ efficiency}\right] * \left[\frac{Hours\ of\ Operation}{year}\right] * \eta$$

ΔE = kW•Hrs reduced (saved) per year per unit

Motor HP = 75HP

% motor loaded = 75%[9].

Motor efficiency = 92% [5, 8, 9]

Hours of Operation per year = 24 hours per day, 5 days per week, 50 weeks per year = 6,000 hrs

η = Efficiency, minimum 3.3%.[2, 10]

$$\Delta E = \; 75\,HP * \left[\frac{0.746\;kW}{HP}\right] * \left[\frac{75\%}{92\%}\right] * \left[\frac{6000hrs}{year}\right] * 0.033$$

$$\Delta \boldsymbol{E} = \frac{\mathbf{9,031}\;\boldsymbol{kW \cdot Hrs}}{\boldsymbol{Year}\; * \mathbf{1}\;\boldsymbol{machine}}$$

Further implied costs and savings are as follows:

O&M Costs per One (1) Hydraulic Manufacturing Unit	**Standard Hydraulic Oil**	**Energy Efficient Hydraulic**	***Cost Savings***
Extended Oil Life			
Annual Hydraulic Change-Outs	1.00	0.10	
Oil Disposal Cost	$80	$8	
Oil costs, annually	$800	$160	**$712**
Labor Savings for Changing Oil			
Man Hours to Change System (hrs)	4	4	
Labor Costs ($/hr)	35	35	
Total Labor Costs	$140	$14	**$126**
Oil Analysis Cost			
Cost of Sampling Program per Year	$0	$0	**$0**
Production Savings and Avoided Downtime Cost			
Lost Production Cost per Hour	$500	$500	
Downtime In Hours	2	0	
Downtime Cost to Change Oil	$1,000	$100	
Pump Replacement Downtime	2	0	
Valve Replacement Downtime	2	0	
Production Savings and Avoided Downtime	$3,000	$400	**$2,600**
Improved Pump and Valve Life			
Pump replacements/year	1	0.1	
Cost for a pump replacement	$1,500	$1,500	
Valve replacements/year	1	0	
Cost of valve replacements	$200	$200	
Annual costs for replacements, $/yr	$1,700	$190	**$1,510**
Energy Costs			**kW-Hr Saved per Unit**
HP to Drive Pumps at full Load	75	72	
KW-Hr Consumed by Pumps	282,689	273,658	**9031**
Annual Electricity Costs	$22,615	$21,893	$722
TOTAL ANNUAL COST SAVINGS			***$5,670***

3 References

1. "HIGH-PERFORMANCE FLUIDS AND COATINGS FOR OFFROAD HYDRAULIC COMPONENTS" December 3, 2019, https://www.energy.gov/sites/prod/files/2019/06/f64/ft082_fenske_2019_o%20REVISED_5.28_4.05pm.pdf

2. "Energy Efficiency of Industrial Oils", December 3, 2019, https://www.tandfonline.com/doi/abs/10.1080/10402009908982281; *Page 775, Conclusion 1: Approximately five-to-eight percent energy are achievable by using energy-efficient industrial lubricants compared with current typical products.*

3. Public Service Commission of Wisconsin, "Evaluation – Business Program: Measure Life Study," Focus on Energy (2009): page 1-4, Table 1-2 Recommended Measure Life by WISeerts Group Description for Building Shell Equip or Tech measure type, accessed December 3, 2019, https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

4. Attachment: Mobil Warranty for Industrial Oils

5. Improving Pumping System Performance: A Sourcebook for Industry" December 3,2019, https://www.energy.gov/sites/prod/files/2014/05/f16/pump.pdf (pg 59 for pump efficiency)

6. Lubricants & Energy Efficiency: Life-Cycle Analysis, December 3, 2019, https://www.sciencedirect.com/science/article/pii/S0167892205800586

7. https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf, Table 3-3, page 3-6.

8. Attachment: Focus on Energy Emerging Technologies Program, EVCO Plastics High Efficiency Hydraulic Fluid Measurement and Verification Study – 2017, ExxonMobil, Confidential, 2020.

9. Determining Electric Motor Load & Efficiency, June 23, 2020: https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

10. Attachment: MPact Plastics Engineering Performance Summary and Data, ExxonMobil, Confidential, 2020.

11. Cut Operating Costs—and Headaches with the Right Hydraulic Oil, December 1, 2019, https://www.ptonline.com/articles/cut-operating-costsand-headaches-with-the-right-hydraulic-oil-

12. Attachment: Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles, 2010, National Academies of Science Engineering Medicine. Also available at http://nap.edu/12845

FOOTNOTE A: There are 159 plastics manufacturers in Pennsylvania in total. We assume that 30% of the equipment will be electric or non-applicable. The remaining 111 are assumed to have 10 plastics manufacturing units, each of which has 1 75-HP electric motor running the hydraulic system. As a note, plastic manufacturers will typically have between 5 and 250 units; we assumed 10 for this calculation.

As demonstrated in the Wisconsin Focus on Energy study and our own in-situ application studies, a 3.3% reduction in energy consumption is noted. Operational time assumes 24 hours per day, 5 days per week, 50 weeks per year. This yields 9,031 kW-Hr per year per unit. With 10 units per site that yields 90 MW-Hr per year.

90 MW-Hr reduced per year for 674 plastics manufacturing companies at this production rate has the potential to reduce 9,990 MW-Hr per year in Pennsylvania.

4 Stakeholder Comments

5 Appendix and Supporting Documentation

Proof of performance

Mobil

Performance by ExxonMobil

Mobil DTE 10 Excel™ 46 hydraulic oil helps U.S. plastics manufacturer reduce energy consumption

Energy lives here™

Plastic injection molding machine | EVCO Plastics manufacturer | DeForest, Wisconsin, United States

Situation

EVCO Plastics is a global plastics manufacturer that operates plastic injection molding machines in its DeForest, Wisconsin plant, all of which were lubricated using a conventional mineral-based lubricant. Because of its long-standing commitment to sustainability in manufacturing, the company is continuously seeking opportunities to minimize energy and resource consumption throughout its operation. For this reason, the company partnered with ExxonMobil to identify a solution that could help improve the energy efficiency of its injection molding machines.

Recommendation

ExxonMobil engineers recommended switching to **Mobil DTE 10 Excel™ 46** hydraulic oil. Formulated with robust anti-wear properties, lower traction coefficient, and shear stable high viscosity index improver (VII). **Mobil DTE 10 Excel 46** is designed to help improve overall hydraulic efficiency. ExxonMobil engineers also recommended implementing routine **Mobil Serv℠ Lubricant Analysis** to monitor fluid and equipment health.

Impact

After transitioning to **Mobil DTE 10 Excel 46**, detailed assessments conducted by both EVCO Plastics and ExxonMobil confirmed a 3.3% reduction in energy consumption in the company's molding machines. As a result, the company was able to reduce overall oil need, energy consumption and overall operating costs.

Benefit

EVCO Plastics reports that **Mobil DTE 10 Excel 46** hydraulic oil helped reduce energy consumption by 3.3%, generating company-estimated annual savings of US $1,353 per plastic molding machine.

Reduced energy consumption by

3.3%

Industrial Lubricants | Advancing Productivity™

Advancing productivity

Helping you reach your Safety, Environmental Care and Productivity goals through our innovative lubricants and services is our highest priority. That's Advancing Productivity. And that's how we help you achieve your broader vision of success.

This Proof of Performance is based on the experience of a single customer. Actual results can vary depending upon the type of equipment used and its maintenance, operating conditions and environment, and any prior lubricant used. In this document, ExxonMobil means Exxon Mobil Corporation or one of its affiliates.

mobil.com/plastics

PROOF OF PERFORMANCE

Mobil Industrial Lubricants

Mobil DTE 10 Excel Helps Plastics Manufacturer to Reduce Energy Consumption and Generate Estimated Annual Savings of USD $1,699/Machine

Arburg Allrounder 820S
Hansen Plastics Corporation
Elgin, Illinois, United States

Situation

Hansen Plastics is a leading plastics manufacturer based in Illinois operating 70 plastic injection molding machines. The high energy demands of these machines led the company to approach ExxonMobil to conduct an energy-efficiency study to help determine an alternative lubrication solution capable of reducing energy consumption while simultaneously providing outstanding equipment protection.

Recommendation

Working with Hansen Plastics, ExxonMobil engineers proposed an energy efficiency study on an Arburg Allrounder 820S machine with the current competitive ISO VG 46 hydraulic oil and **Mobil DTE 10 Excel™ 46** hydraulic oil. Formulated with selected base oils and a proprietary additive system, **Mobil DTE 10 Excel 46** is scientifically engineered to help provide exceptional hydraulic system efficiency, including potential energy efficiency benefits.

Result

Hansen Plastics maintenance personnel reported the energy efficiency study results definitively showed the plastic injection molding machine experienced a 5.1% reduction in energy consumed when using **Mobil DTE 10 Excel 46** hydraulic oil. In addition, a productivity improvement of 0.21 second average cycle time reduction was experienced operating with **Mobil DTE 10 Excel 46**. These improvements resulted in a company estimated annual energy savings of $1,699 for this machine.

The evaluation performed by the Hansen Plastics maintenance team and ExxonMobil engineers measured power consumption and cycle time under matching production conditions during the reference and test periods. In addition, equipment operation of material used and material throughput per hour were similar. Convinced of the performance of **Mobil DTE 10 Excel 46** hydraulic oil, the Hansen Plastics plans to convert the additional machines to help improve operational efficiency.

Advancing Productivity*

Mobil DTE 10 Excel 46 hydraulic oil helped Hansen Plastics Corporation improve the energy efficiency of its plastic injection molding machines, and improve production cycle times.

For more information on Mobil-branded industrial lubricants and services, please contact your local company representative or visit mobilindustrial.com.

*This Proof of Performance is based on the experience of a single customer.
Actual results can vary depending upon the type of equipment used and its maintenance, operating conditions and environment, and any prior lubricant used.

PROOF OF PERFORMANCE

Mobil™ Industrial Lubricants

Mobil DTE 10 Excel 46 Helps Cement Producer Increase Hydraulic Efficiency and Performance, Generating an Annual Savings of More Than USD $4,300

Seram-Equilibrium Crane
Cement Producer
Missouri, United States

Situation

A Missouri-based cement producer uses a Seram-Equilibrium crane to unload barges of raw material. Periods of very low temperatures during the winter months created start-up delays in the crane's hydraulic system, which wasted valuable production time. The company approached ExxonMobil to provide reliable options for reducing start-up delays, increasing hydraulic efficiency and improving oil durability.

Recommendation

ExxonMobil engineers recommended **Mobil DTE 10 Excel™ 46** hydraulic oil. This premium-performance lubricant is formulated with a high viscosity index, which helps maintain maximum hydraulic efficiency and component protection over a wide temperature range.

Result

Use of **Mobil DTE 10 Excel 46** hydraulic oil helped eliminate winter start-up delays, and improved productivity through estimates of reduced cycle time by two percent and improved fuel efficiency by 0.5 percent. Collectively, these benefits helped the cement producer improve hydraulic efficiency, availability and productivity, generating annual cost savings of USD $4,313.

The product performance of **Mobil DTE 10 Excel 46** hydraulic oil, alongside the application expertise provided by local ExxonMobil engineering support, is helping to improve customer productivity potential.

***Mobil DTE 10 Excel 46** hydraulic oil helped a cement producer improve hydraulic system performance on this Seram-Equilibrium crane, saving more than USD $4,300 per year.*

For more information on Mobil Branded Industrial Lubricants and services, call your localcompany representative or visit www.mobilindustrial.com.

www.mobilindustrial.com

POP 2011-045

This Proof of Performance is based on the experience of a single customer. Actual results can vary depending upon the type of equipment used and its maintenance, operating conditions and environment, and any prior lubricant used.

ENERGY SAVING STRATEGIES FOR PLASTICS INJECTION MOLDING: LUBRICATION

ADAM MCMURTREY, EXXONMOBIL, SPRING, TX

Abstract

Plastics injection molding machines require an extensive amount of energy, and energy costs typically represent one of the major line items in a company's operating budget. A typical injection molding operation spends almost as much on energy expenditures as it does on direct labor. As operators look to reduce costs and enhance sustainability, they typically turn to the more obvious levers – such as new equipment, lighting retrofits, and more. But, one of the easiest and most frequently overlooked opportunities to improve energy efficiency is lubrication. This paper outlines how lubrication influences energy efficiency, key lubrication-related energy saving opportunities, and how operators can implement the right lubrication strategy to reduce energy costs, improve their bottom line, and enhance sustainability.

Introduction

Plastics injection molding machines require an extensive amount of energy, and energy costs typically represent one of the major line items in a company's operating budget. A typical injection molding operation spends almost as much on energy expenditures as it does on direct labor. As operators look to reduce costs and enhance sustainability, they typically turn to the more obvious levers – such as new equipment, lighting retrofits, and more. But, one of the easiest and most frequently overlooked opportunities to improve energy efficiency is lubrication. This paper outlines how lubrication influences energy efficiency, key lubrication-related energy saving opportunities, and how operators can implement the right lubrication strategy to reduce energy costs, improve their bottom line, and enhance sustainability.

Injection molding machines: optimizing for energy efficiency

Today's plastic injection molding machine technology is far more energy efficient than 20 years ago. At a conservative estimate, modern hydraulic plastic injection molding machines are 25% more energy efficient than those manufactured in 1997. Meanwhile, today's best all-electric machines may be up to 80% more energy efficient than their 20-year old hydraulic predecessors.

But, in almost every case, the cost of energy required to run a plastic injection molding machine over a 10- year period will be greater than its initial purchase cost. This cost gap will only widen as energy prices increase.

For this reason, energy assessment must become part of the purchasing process for every new plastic injection molding machine. Considering the whole life cost of a machine is difficult but it is the only way to control future energy expenditure. It will help ensure that an attractive low cost machine does not become an energy hog that raises production costs through its entire lifetime. This includes looking at every aspect of the machine's operation – down to the lubricant used.

Check your hydraulic oil

Hydraulic oil expenditure represents a fraction of the cost of running plastic injection molding machinery. But, a small change in hydraulic oil can result in big performance breakthroughs, such as prolonged component life, improvements in overall equipment efficiency and reduced cycle times.

Operating challenges

Throughout the injection molding process, hydraulic oil is exposed to compression, shear stresses and a wide range of temperatures. Exposure to these conditions can trigger molecular breakdown in the oil, reducing its ability to lubricate and protect machine components. A conventional or lower quality hydraulic oil offers less lubricity and protection, forcing equipment to work harder – ultimately exerting more energy.

High temperature operating conditions will also cause oxidation within the hydraulic oil, which subsequently creates an increase in viscosity and a build of destructive lacquer. Along with oxidation and corrosion, hydraulic oils can also become contaminated by water, dust, wear debris and other materials throughout the injection molding process.

Contamination triggers pump failures and ultimately increases filtration costs.

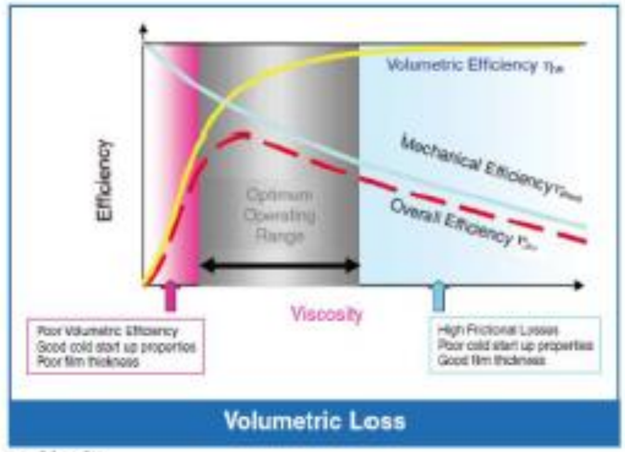
Switch to advanced hydraulic oil

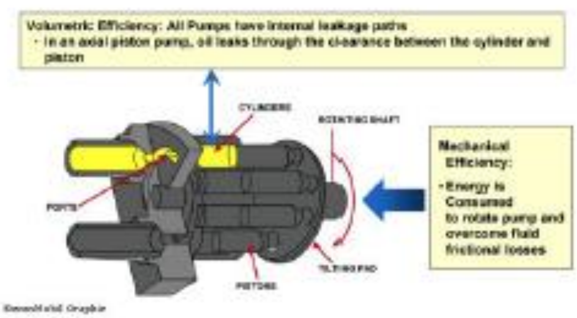
To combat all of these issues, it is important to use a hydraulic oil with excellent shear stability and a high viscosity index. High performance hydraulic oils maintain their optimum viscosity across a wide range of operating conditions, helping to protect equipment, improve energy efficiency and extend oil drain intervals. That, in turn, can help to reduce maintenance, cut costs and enhance operational safety by reducing employee interaction with machinery. Extending oil drain intervals can also cut waste lubricant disposal, improving a company's overall environmental credentials.

The science behind advanced hydraulic oils

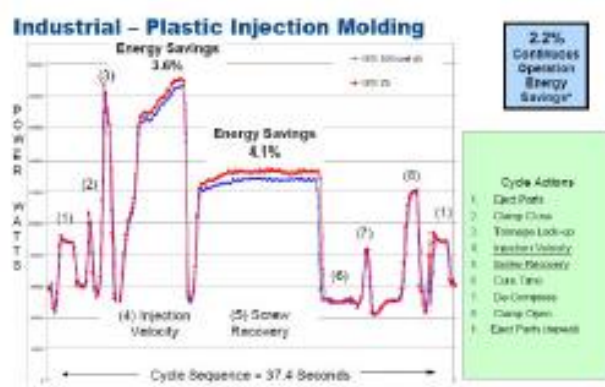
In hydraulic systems, a pump cannot be 100% efficient in its energy conversion, typically losing energy in two main areas: mechanical losses, where energy is lost to friction; and, volumetric losses, where energy is lost as a result of internal fluid leakage. Both types of energy loss are primarily a function of the hydraulic fluid's viscosity and lubricity properties. Specially formulated high performance hydraulic fluids can reduce the magnitude of both mechanical and volumetric losses by utilizing a high viscosity index.

Viscosity index (VI) is an empirical and unit-less number used to specify the fluctuation in viscosity with respect to temperature. The viscosity of a fluid with a high VI does not change as rapidly with temperature when compare to a fluid with a lower index. The technology advantages of a higher VI include increased energy efficiency and a reduction in power consumption, as well as a longer operating life and cleaner oil. Together, these benefits help the equipment suffer less "energy loss" during the normal course of operation.





As shown in the graph below, which maps the energy consumption of an injection molding machine when using a conventional hydraulic oil (red line) compared to a more advanced oil (blue line), the more advanced oil delivers significant energy savings at key moments during operation.



Identifying the energy efficiency opportunity

To properly identify if lubrication can in fact deliver valuable energy efficiency savings, operators should take advantage of several lubrication-related services.

First, many suppliers offer energy efficiency studies, whereby the supplier's engineering team conducts a full energy study. The process often entails close collaboration with your maintenance team to do the following:

- Determine objectives, expectations, focus and scope
- Coordinate and oversee pre-test, test and post-test work
- Develop a detailed test protocol
- Respect all safety and labor rules and ensure complete confidentiality
- Document results and recommendations

These studies end with a full report that details the right lubrication technologies and maintenance practices that operators should follow to reduce equipment energy consumption.

In addition to a full energy efficiency study, operators should take advantage of a regular used oil analysis program. This program can deliver invaluable insights into how both a machine and its respective lubricant are performing, helping operators take corrective action as needed to maintain optimal equipment performance and efficiency.

Lubrication as an energy efficiency lever: field examples

Two recent examples from the field highlight the significant energy efficiency benefits that lubrication can deliver.

In one instance, a leading plastics manufacturer switched to a higher performance hydraulic oil for its Arburg Allrounder 820S injection molding machines, leading to a 5.1% reduction in energy consumption. In addition to enhancing energy efficiency, the new lubricant enhanced the overall efficiency of the equipment, reducing maintenance costs and improving safety through a decrease in human-machine interaction.

In another example, a Wisconsin-based plastics manufacturer was able to reduce the electricity demand in a Van Dorn 300HT24 plastic injection molding machine by 3.3% by switching to a high viscosity index hydraulic fluid. The company partnered with its lubricant supplier to conduct a full energy efficiency study to verify the results. This study was also conducted in partnership with Wisconsin's statewide energy efficiency program, which validated the hydraulic fluid as an energy-efficient technology under its energy efficiency incentive program. To qualify as energy efficient, the oil was required to demonstrate that it provided users with a payback between one-and-a-half and eight years, depending on operating conditions.

Conclusion

New lubrication technologies are providing plastics injection molding companies with new opportunities to help reduce energy consumption and improve profitability and sustainability. However, to take advantage of these opportunities, operators must understand the role that lubrication plays in driving equipment efficiency as well as the lubrication-related services that can help identify the true opportunity.

Energy Efficient Industrial Lubricants

Data Collection - Industrial Hydraulics

*All Data Should be based on a single piece of equipment

Total Pieces of Equipment: 1

HYDRAULIC BASE DATA				
Reservoir Size	80	Gallons		
Number of Pumps	1	#	(How many pumps are driven by the engine?)	
Nominal System Operating Pressure	2000	PSI	(What is the typical (not max) operating pressure)	
Nominal Pump Flow Rate	64	GPM	(What is the rated pump output; can use average of pumps)	
% Time at Full Load	75%	% of time	(What % of run time is the system loaded)	
% Time at Idle	25%	% of time	(What % of run time is the system idling)	
Current Hydraulic Oil Cost	10.00	$/gallon		
DTE 10 Excel Cost	20.00	$/gallon		
Current Oil Change Interval	1	per	1	years
DTE 10 Excel Oil Change Interval	1	per	10	years
Typical Makeup Rate	4%	%		
Electric Motor Efficiency	92%	%		
Electric Cost	0.08	$/kw-hr		
Expected Efficiency	3.3%	%	(See Chart)	

PRODUCTION & LABOR DATA:		
Production Value or Cost	500	$/Hour
Operating Hours per Day	**24**	Hours
Operating Days per Year	**250**	Days
Labor Costs	35	$/Hour
Time to Change System	2	Hours
Number of People to Change System	2	Number of people

HYDRAULIC PUMP & VALVE REPLACEMENT COST:		
Pump Replacements Per Year	1	Pumps per Year
Cost of a Pump Replacement	1500	$ per Pump
Time to replace pump	2	Hours to Change A Pump
Expected Pump Replacement w/ 10 Excel	0.1	Pumps per Year
Valves Replaced Per Year	1	Valves per Year
Cost of Replacement Valves	200	$ per Valve
Time to replace valves	2	Hours to Change a Valve
Expected Valve Replacement w/10 Excel	0.2	Valves per Year

OIL ANALYSIS INFORMATION:		
Signum Oil Analysis Samples	0	Number per Year
Signum Oil Analysis Cost	0	$/Sample
Current Hydraulic Samples	0	Number per Year
Current Hydraulic Sample Cost	0	$/Sample

RESERVOIR FLUSHING/CLEANING COST:		
Amount of Flush Oil	0	Gallons of Flush Oil Needed
Cost of Flush Oil	0	$/Gallon (not a price quote)
Cost of Oil Disposal	1	$/Gallon (not a price quote)
If the facility will COT-Purtech to conduct the flush, complete the following:		
Estimated Cost for COT to Flush the Hyd U	0	$/Unit (not a price quote)
If the facility will use their personnel to conduct the flush, complete the following:		
Number of Personnel to Conduct Flush	0	Number of People
Time to Flush Each System	0	Hours to Flush a System

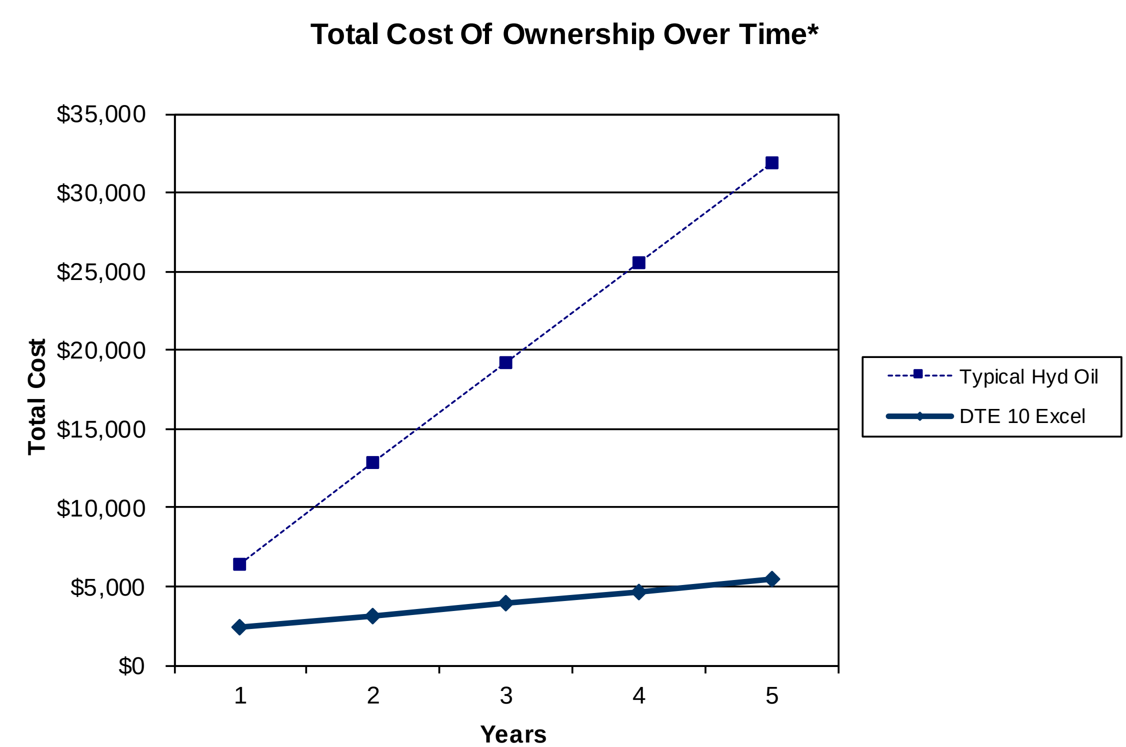
Mobil Industrial Lubricants

Fuel Cost Per Day											
Pump Efficiency Increase	**0%**	**1%**	**2%**	**3%**	**4%**	**5%**	**6%**	**7%**	**8%**	**9%**	**10%**
HP Required to Drive Pumps	75	74	73	73	72	71	70	70	69	69	68
KW-HR Consumed	275,495	272,767	270,093	267,471	264,899	262,376	259,901	257,472	255,088	252,748	250,450
Electricity Costs for the Year	$22,040	$21,821	$21,607	$21,398	$21,192	$20,990	$20,792	$20,598	$20,407	$20,220	$20,036
Total Fuel Costs											
Difference in Annual Electricity Costs	-	$218	$432	$642	$848	$1,050	$1,248	$1,442	$1,633	$1,820	$2,004
CO2 Difference Per Year	*-*	*1.7*	*3.3*	*4.9*	*6.4*	*8.0*	*9.5*	*10.9*	*12.4*	*13.8*	*15.2*

O&M Costs per One (1) Hydraulic Manufacturing Unit	**Standard Hydraulic Oil**	**Energy Efficient Hydraulic**	***Cost Savings***
Initial Fill			
Total Hydraulic Reservoir Capacity, gal	80	80	
Product Cost, $/gal	$10.00	$20.00	
Total Hydraulic oil costs, initial fill	$800	$1,600	**($800)**
Initial Flushing/Cleaning Cost			
Flush Oil Cost	0	*$267*	
Flush Oil Disposal	0	*$27*	
Machine Flushing Cost	$0	$35	**($328)**
Extended Oil Life			
Annual Hydraulic Change-Outs	1.00	0.10	
Oil Disposal Cost	$80	$8	
Oil costs, annually	$800	$160	**$712**
Labor Savings for Changing Oil			
Man Hours to Change System (hrs)	4	4	
Labor Costs ($/hr)	35	35	
Total Labor Costs	$140	$14	**$126**
Oil Analysis Cost			
Cost of Sampling Program per Year	$0	$0	**$0**
Production Savings and Avoided Downtime Cost			
Lost Production Cost per Hour	$500	$500	
Downtime In Hours	2	0	
Downtime Cost to Change Oil	$1,000	$100	
Pump Replacement Downtime	2	0	
Valve Replacement Downtime	2	0	
Production Savings and Avoided Downtime	$3,000	$400	**$2,600**
Improved Pump and Valve Life			
Pump replacements/year	1	0.1	
Cost for a pump replacement	$1,500	$1,500	
Valve replacements/year	1	0	
Cost of valve replacements	$200	$200	
Annual costs for replacements, $/yr	$1,700	$190	**$1,510**
Energy Costs			**kW-Hr Saved per Unit**
HP to Drive Pumps at full Load	75	72	
KW-Hr Consumed by Pumps	282,689	273,658	**9031**
Annual Electricity Costs	$22,615	$21,893	$722
TOTAL ANNUAL COST SAVINGS			***$5,670***

Energy Efficient Hydraulic Oil versus Typical Hydraulic Oil Total Cost of Ownership

The Total Cost of Ownership (TCO) of the hydraulic systems is all of the cost involved in keeping them operational. The TCO includes the cost of oil, sampling, labor, lost production and fuel. Therefore, the first year of using an Energy Efficient Hydraulic Oil may involve a higher cost per gallon and the potential need to flush or clean the hydraulic systems. As you see in the graph below, the real TCO of the systems then begins to improve with Mobil's EE Hydraulic oil because of the ability and performance of the product.



*Year 1 does not include electricity costs. Years 2 through 5 include only electricity cost differential

	Typical Hyd	DTE 10 Excel
Year One	$6,440	$2,399
Year Two	$12,802	$3,163
Year Three	$19,165	$3,927
Year four	$25,527	$4,691
Year five	$31,890	$5,455