Technical topic

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Hydraulic efficiency

Energy lives here™

Today's globally competitive business world drives manufacturers to get the most out of their equipment. Even small increases in machine productivity can mean the difference between profit and loss. Additionally, environmental concerns demand focus on sustainable business practices and energy-efficient systems. In response, industrial and mobile equipment hydraulic systems have become smaller and lighter, and utilize higher pressures to achieve maximum system efficiency. Now, advanced hydraulic fluids are available to meet the demands of these systems, as well as to contribute to overall hydraulic system and energy efficiency.

Hydraulic efficiency: Theory

Hydraulic systems convert mechanical energy input from an electric motor or internal combustion engine into fluid flow and pressure that can accomplish a specified amount of work.

Hydraulic pumps convert the mechanical energy of the prime mover into fluid flow. Pressure is generated by the restriction of this flow in the system.

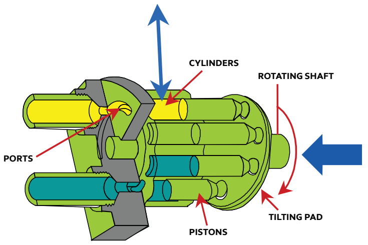
A typical hydraulic pump is only 80-90% efficient.

The energy is lost in two main forms.

- **Mechanical losses – energy lost to fluid friction**
- **Volumetric losses – energy lost as the result of internal fluid leakage (slippage) within the pump.**

Hydraulic pump

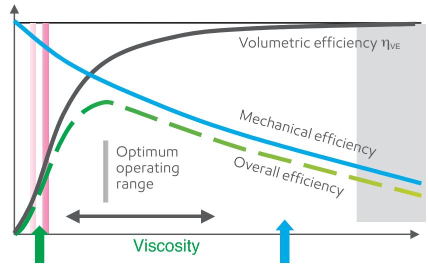
Volumetric efficiency: All pumps have internal leakage paths
▪ Axial piston pump – oil leaks through the clearance between the cylinder and piston



Mechanical efficiency:
▪ Energy is consumed to rotate pump and overcome fluid frictional losses

The amount of mechanical and volumetric loss in a pump is primarily a function of the fluid's viscosity and lubricity properties. This is shown on the graph below.

Volumetric loss



Poor volumetric efficiency
Good cold startup properties
Poor film thickness

High frictional losses
Poor cold startup properties
Good film thickness

Mechanical losses are highest when fluid viscosity is high and volumetric losses are highest when fluid viscosity is low. Viewing these two curves on the graph illustrates a viscosity range for optimal efficiency. Because hydraulic fluid viscosity is high at low temperatures and decreases as the fluid temperature rises, staying within this optimal operating range is not simple. Specially formulated hydraulic fluids can reduce the magnitude of these losses by utilizing a high viscosity index to maintain fluid viscosity in the optimum range across a wide operating temperature range. Increasing system pressure also reduces hydraulic pump efficiency. Higher pressures generally lead to both increased mechanical losses (there are higher loads on the pump) and increased volumetric losses (higher pressures increase the amount of internal leakage).

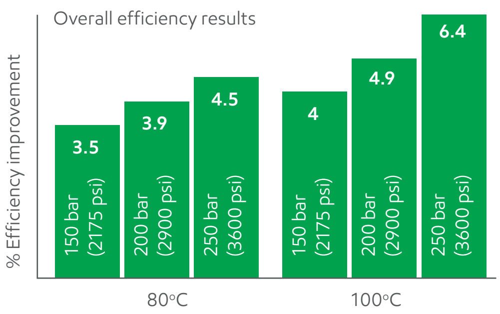
In addition to the hydraulic efficiency benefits from maintaining hydraulic fluid viscosity in the optimum range, additional efficiency gains can be achieved through selection of optimal base fluids and additive technology to reduce traction – the inherent resistance of the fluid to shear under Elasto Hydrodynamic Lubrication (EHL) conditions.

Theory into practice

Differences in hydraulic efficiency can be quantified by comparing two fluids in a simple circuit. The circuit contains a hydraulic pump and the system pressure is controlled over a specified range. The mechanical energy input to the system and the flow rate can then be measured and used to calculate the mechanical and volumetric efficiency of two different fluids.

The following graph shows the comparison between a typical ISO VG 46 antiwear hydraulic fluid and specially formulated high VI test fluid. The test fluid demonstrates a hydraulic efficiency increase between 3 and 6 percent in this bench test. As temperature and pressure increase, the efficiency benefit increases.

Efficiency – Mobil DTE 10 excel™



This demonstration shows the impact that fluid formulation and physical characteristics can have on overall hydraulic efficiency. But hydraulic efficiency is not an end goal in and of itself. This additional pumping efficiency can translate into energy savings, as measured by fuel or electricity consumption, or in time to complete a work cycle in hydraulically powered equipment.

Hydraulic efficiency = Productivity improvements

To demonstrate the impact of hydraulic efficiency on energy consumption and cycle time a study was conducted on an excavator. In an excavator hydraulic system pressures can reach 4,000 psig (275 bar) and temperatures often approach 100°C.

A demonstration was arranged to compare a typical SAE 10W fluid, commonly used in mobile equipment applications, with a hydraulic fluid specifically designed to optimize hydraulic efficiency*. Using the hydraulic fluid offered:

up to 6% less fuel per cycle*

up to 5% less time per cycle*

The machine operator also noted that the responsiveness of the system improved immediately upon addition of the test fluid.

Use of this specifically designed hydraulic fluid for a full year in a medium sized excavator would:

reduce fuel usage by up to **900 gallons***

reduce CO2 emissions by up to **9 metric tons***

Similar energy savings opportunities exist in industrial hydraulic applications. A prime example is plastic injection molding, which is characterized by relatively high temperatures and pressures, large power consumption, repeated cycles, etc. Use of efficient hydraulic fluids in plastic injection molding machines can be expected to reduce energy consumption and increase cycle times.

Conclusion

Proper hydraulic fluid selection can improve the bottom line:

- **Reducing efficiency losses**
- **Increasing energy savings**
- **Increasing productivity**

*Demonstration used a medium-sized excavator with a single operator and batch of fuel. Results may vary depending on operating conditions.