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. Unfortunately, the hydraulic pump cannot be 100% efficient in this energy conversion. A typical hydraulic pump is only 80-90% efficient in this process. 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.

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 hydraulic 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 from the pump can then be measured and used to calculate the mechanical and volumetric efficiency of two different fluids.
The following graph shows this comparative data between a typical ISO VG 46 anti-wear hydraulic fluid and specially formulated high VI test fluid. The test fluid demonstrates a hydraulic efficiency increase between 3% and 6% in this bench test. Note that as temperature and pressure increase, the efficiency benefit of the test fluid increases.

A demonstration was arranged with a medium sized excavator to compare a typical SAE 10W fluid, commonly used in mobile equipment applications, with a hydraulic fluid specifically designed to optimize hydraulic efficiency. For the purpose of this demonstration, a single operator and batch of fuel was used to operate the excavator through a prescribed set of motions. In this demonstration, application of efficient hydraulic fluid resulted in up to 6% reduction in fuel per cycle and a decrease of up to 5% in time to complete each work cycle.* The machine operator also noted that the responsiveness of the system improved immediately upon addition of the test fluid.

The results of this demonstration clearly show the impact of increasing hydraulic efficiency: reduced fuel consumption or increased productivity! Use of this specifically designed hydraulic fluid for a full year in a medium sized excavator would reduce fuel usage by as much as 900 gallons and reduce CO₂ emissions by as much as 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:**
Applying knowledge of how hydraulic efficiency can be improved through proper hydraulic fluid selection can help increase the bottom line. Utilizing a well-formulated hydraulic fluid can help reduce efficiency losses in hydraulic systems, leading to energy savings and increased productivity.

* Results may vary depending on operating conditions.

www.mobilindustrial.com

© 2009 Exxon Mobil Corporation
Mobil and the Pegasus design are registered trademarks of Exxon Mobil Corporation or one of its subsidiaries.

HY8012SH