Better Energy-Efficient Flow Rate Regulation

Reducing Energy Consumption by Implementing Variable Speed Drive Concepts

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Introduction

Implementing a power-on-demand concept based on variable speed drives allows for energy saving in any application that involves pumps or hydraulic systems. And when used in combination with an intelligent wiring and communication system, relevant machine data can also be easily recorded — the basis for comprehensive power management.

Using energy efficiently not only saves companies money, but also saves resources and combats climate change. Pumps are an important starting point in improving energy efficiency, as they are among the largest industrial electricity consumers. On average, roughly 45% of the total costs related to a pump's service life are energy costs.

Low-Cost or High-End

Nevertheless, there exists great potential for pumps vis-à-vis energy savings — especially for pump applications and engines based on hydraulic technology. However, the overwhelming majority of applications currently in use are operated by motors and pumps running at a constant speed.

Take, for instance, hydraulic power units which now are typically constructed from inexpensive, asynchronous motors, motor starters and fixed-displacement pumps — all of which require relatively small investment. And yet they consume a large amount of energy, given that the overall hydraulic power unit is designed to support the maximum pressure and volume flow required. Energy is wasted because it delivers this maximum output — whether application-driven or not. In addition, heat inflow into the hydraulic fluid via the constantly operating pump is high, so additional cooling capacity is required.

To increase the energy efficiency of such a system, the fundamental approach is to operate the main pump of the machine at variable speed. Thus, only the *required* power is made available to the system whenever needed.

As a high-end solution, this can be achieved with a four-quadrant, direct drive; i.e., a servo drive controls the speed of the pump and, therefore, the pressure and volume flow. In this case the oil need only be actively cooled to a limited extent.

All in all, such a unit consumes significantly less energy than a system with constant pressure. However a direct drive can only supply one process. If hydraulic power is needed for several different processes, an equivalent number of power units are required. The four-quadrant, direct drive with servo motors is thus a solution that belongs at the upper end of the scale in terms of required investment.

Cost- and Energy-Efficient Solution with Speed Control

Eaton provides a more cost-effective alternative. In this solution a variable speed starter or variable frequency drive takes over the control of the speed of the pump — i.e., with vari-

Figure 1 The machine model jointly developed by Eaton and solution partner ATP Hydraulik is based on three different drive concepts and demonstrates potential energy efficiency gains. (All images courtesy Eaton Corp.)

Figure 2 Through integration of an intelligent wiring and communication system, the hydraulic power unit is already IoT-ready, meaning that mechanical engineers and end users can, regardless of location, obtain an up-to-date, detailed overview of all relevant data, such as temperature and pressure.

able frequency drive more complex functionalities can be handled, *and* the variable speed starter is more cost-effective and easier to put into operation.

A conventional asynchronous motor is used as a drive, whereby motors from the IE2 to IE4 efficiency classes can be used, depending on operating cycles and runtimes. A further increase in energy efficiency can be achieved by using permanent magnet motors, but that also involves higher investment costs.

The motor control unit receives data from a sensor about the pressure in the hydraulic system and, based on this, adjusts the motor's speed to the volume flow requirement of the hydraulic devices consuming the energy. This power-on-demand concept also can supply several parallel processes with similar volume flows and pressure requirements, thereby controlling various actuators via direction control and proportional or servo valves. At the same time, users of this configuration will also benefit from longer machine life due to lower levels of heat generation, increased operator safety, compact design, and improved comfort by reducing pump noise.

Energy Savings of More Than 50%

With a machine model that was jointly developed with solution partner ATP Hydraulik AG (*info@atphydraulik.ch*), Eaton was able to illustrate the energy efficiency of this drive concept. Three hydraulic units were operated in parallel; one system was a basic solution controlling the motor and pump at a constant speed; the second was the servo solution using the servo controller; and, in the third, a variable speed starter controlled the main pump based on the power required. Therefore this machine model allows a direct comparison to be made of the units in terms of dynamics, energy consumption and total cost of ownership (TCO). The advantages of the variable speed hydraulic power unit were clear. Based on the basic solution, it could be proven that the power-on-demand concept meant achieving energy savings of approximately 60%.

Eaton has also confirmed this saving potential in practice as part of a retrofit measure on a 20-year-old, 50 t injection molding machine. To date, their hydraulic unit has been constantly driven with a conventional 15 kW asynchronous motor. The volume flow of the pump is mechanically controlled; even at low-volume flow, the motor drives the pump at a constant speed of 1,500 revolutions and so consumes large amounts of energy. This drive was upgraded using a variable frequency drive (Eaton PowerXL DA1), a permanent magnet motor and an axial piston pump (Eaton 425 piston pump). By making the control of the motor load-dependent and only providing it with the power that the process requires, energy consumption can be reduced from 5.6 kWh to 2.8 kWh, or by around 50%. Assuming that the machine operates for two eight-hour shifts, 300 days a year, the annual energy savings for each machine amount to EUR 2,016 ($2,257 U.S.). The period for achieving return on investment (ROI) in this case is 2.2 years.

IoT-Ready for Cloud-Based Power Management

However, reducing energy consumption is only the first step towards an energy-efficient system. The next is to create the conditions for a power management system. Extensively recording and analyzing energy and machine data are the only possible ways to monitor energy consumption, thus identifying opportunities for improvement and checking the impact of the measures implemented. This requires the use of numerous sensors, such as for measuring pressure, positions or temperature, as well as for recording information about the operational status of each individual component.

In the case of a traditional set-up where individual cables are connected, this translates to considerable, additional reliance upon wires and cables for transmitting the information from the relevant component to the programmable logic controller (PLC). An intelligent wiring system at the device level, such as Eaton's SmartWire-DT, offers clear advantages in comparison. It allows components such as switching devices, circuit breakers, pushbuttons, sensors and actuators to be connected to each other using a single cable instead of using elaborate point-to-point wiring. The cable supplies power to the connected devices while also supporting data communication. At the same time, standard components are turned into intelligent, communication-enabled devices using an ASIC module.

As the I/O modules of SmartWire-DT are available with IP67-rated protection, sensors and actuators can also be con-

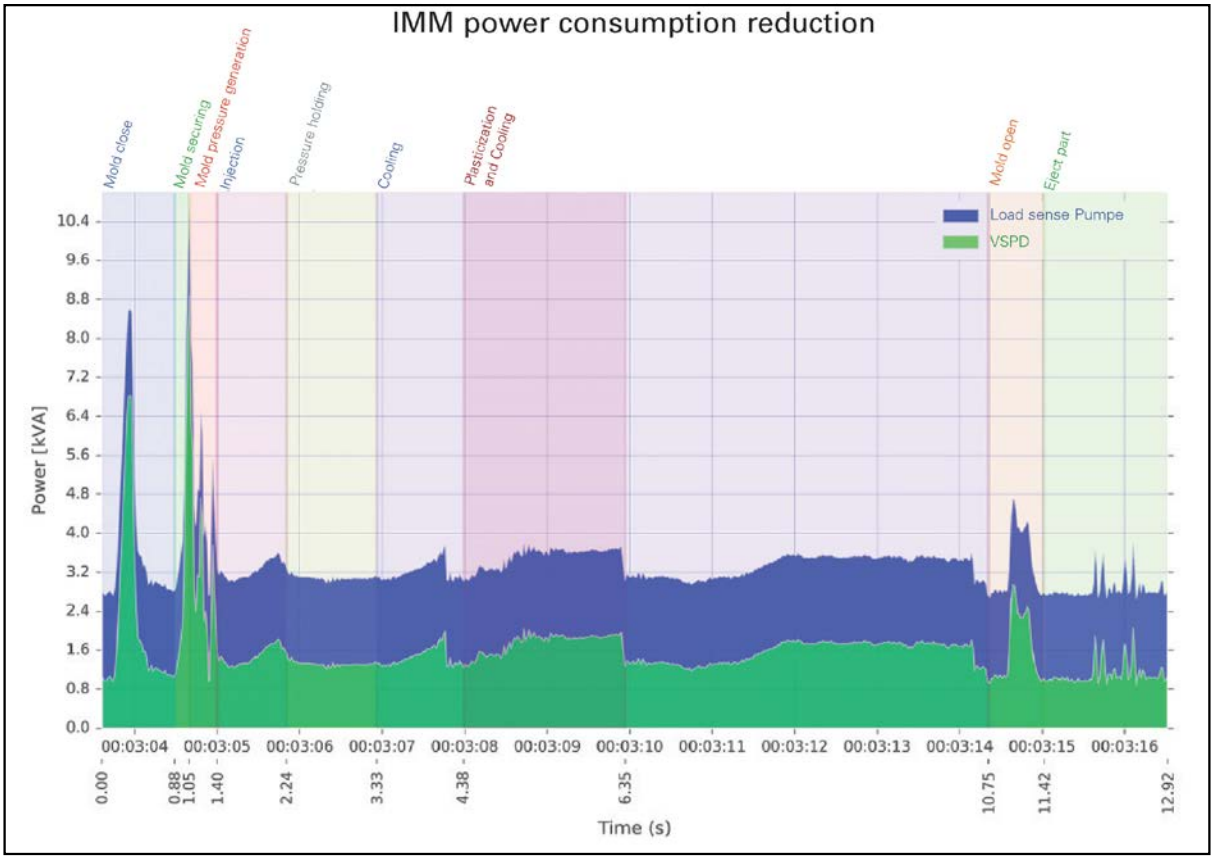

Figure 3 Thanks to a retrofit project, an injection-molding machine achieved energy savings of around 50%.

nected in the field. This means that data from a machine or system monitoring vertical movement of cylinder, temperature or pressure can be easily recorded and used for power management. By using gateway modules, SmartWire-DT makes it possible for users to connect the system to all popular controls and fieldbus systems, such as Profibus, Profinet, CANopen, Modbus TCP, Ethernet/IP, Powerlink or EtherCAT — and to the Internet — therefore making it IoT-ready. If control devices are used with an OPC UA interface, all data — down to device level — can, for instance, be supplied for cloud-based, power management software. **PTE**

NOTE: *Eaton white paper — "Planning and Operating Hydraulic Power Units to Provide Greater Energy Efficiency" — provides additional information on this subject. It is available (in English) for free download at: www.eaton.eu/moem-ee.*

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