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Variable-Speed Pump Drives Save Energy, Cut Noise and Heat

Compared to a variable-displacement pump driven by a constant-speed motor, a pump powered by a variable-speed drive can cut energy costs, lower heat and noise generation, and reduce reservoir size.

The use of variable-speed electric drives to power hydraulic pumps has grown with the development of high-speed controls, quick-response motors, and improved software that give these motor-pump combinations the power and responsiveness to match systems controlled by electrohydraulic valves or a variable-displacement pump, while also reducing energy consumption.

Traditionally, constant-speed ac induction motors have been used to drive the pumps in stationary hydraulic systems, with hydraulic power controlled by flow- and pressure-regulating valves or a variable-displacement pump. However, the constantly-running motor can consume as much as 50% of full-load current, even when the system is not under load. In addition, pumps and motors in conventional hydraulic power units (HPUs) often are oversized to meet maximum duty-cycle demands. By contrast, a variable-frequency drive or servodrive can manage an electric motor's operating torque and speed more efficiently. Instead of running continuously at full speed, the motor rotates only fast enough to meet system demand at any given time.

A hydraulic system with a variable-speed drive combines the robust, power-dense benefits of hydraulics with the intelligence and ease of integration into automation systems provided by electric drives. Energy efficiency is increased because pump speed is easily adjusted to flow demands, and the motor isn't running constantly at high speed, regardless of load. Noise is also reduced, especially during operations where pump flow demand is below maximum. Varying the pump speed varies the flow and therefore matches the hydraulic power delivered to the exact amount needed at any point in a machine's duty cycle, whether during operation, in standby, or while maintaining pressure. In addition, because these systems generally require less oil and consequently a smaller reservoir, the machine footprint can be reduced.

Although variable-speed drives commonly are paired with fixed-displacement pumps, additional benefits can come from teaming a variable-speed drive with a variable-displacement pump in many applications. "By combining a variable-speed electric drive and a variable-displacement hydrostatic drive, we can drastically reduce the motor size, which lowers both installation costs and electrical parasitic losses," says Rashid Aidun, application engineer—VAS team, Parker Hannifin.

"Combining a high-response variable-displacement pump with a VFD-controlled induction motor results in greater efficiency and a much higher system response than a variable-speed unit alone," adds Paul Stavrou, manager of system applications, Bosch Rexroth. "Using a variable-displacement piston pump makes it possible to adjust pressure, pump displacement, and motor speed (torque and speed) to optimal working points, thereby minimizing electric, hydraulic, and mechanical losses."

In many cases, variable-speed pump drives are used to power hydraulic motors in applications such as mobile or material handling equipment. However, they provide equal benefits when used to power actuators. Electrohydraulic actuators (EHAs) combine the best of electromechanical and electrohydraulic technology to convert power from electric to hydraulic to mechanical. EHAs are attractive in applications such as machine tools, since the actuators only consume power when the systems demand it. They also eliminate the need for thermal management, as well as oil and filter changes.

The benefits of variable-speed pump drives are paying off in applications that include machining and metal forming equipment, plastics and rubber machinery, die casting machines, pulp and paper machinery, hydraulic test stands, material handling equipment, and many other industrial applications.

Kyntronics, Eastlake, Ohio, has developed a self-contained modular actuator that not only drives a hydraulic pump with a variable-speed motor, but also incorporates volume com-pensation to account for piston rod volume. By employing a technology known as electrohydraulic actuation (EHA), it combines most of the advantages of hydraulics with those of electromechanical actuators, but without many of the disadvantages.

An EHA typically integrates a hydraulic cylinder with a controller, motor, pump, reservoir, and control manifold into a self-contained solution. The Kyntronics solution combines a drive, servomotor, manifold, and cylinder within a self-contained package. A key element of the Kyntronics EHA is a rod-volume compensating mechanism, which compensates for the differential volume between the cylinder's rod- and cap-end volumes as the piston rod extends and contracts.

The modular system starts with a bidirectional ac or dc servomotor driving a gear pump. This eliminates the need for a proportional directional valve because the motor controls flow rate and direction. One beneficial feature is the way the system accounts for the differential volume between a cylinder's cap and rod ends. To compensate for this difference, the hydraulic cylinder includes an outer low-pressure cylinder, which creates a chamber between the two cylinders. This chamber con-tains compressible foam that serves the same purpose as an accumulator in a conventional system, but the foam does not require an initial precharge or any maintenance.

Kyntronics developed this electrohydraulic actuator, a self-contained modular assembly that contains a complete hydraulic system. Power is transmitted by a variable-speed motor and control that drive a hydraulic gear pump, while built-in transducers provide closed-loop force and position control.