Combining energy efficiency and dynamic hydraulics

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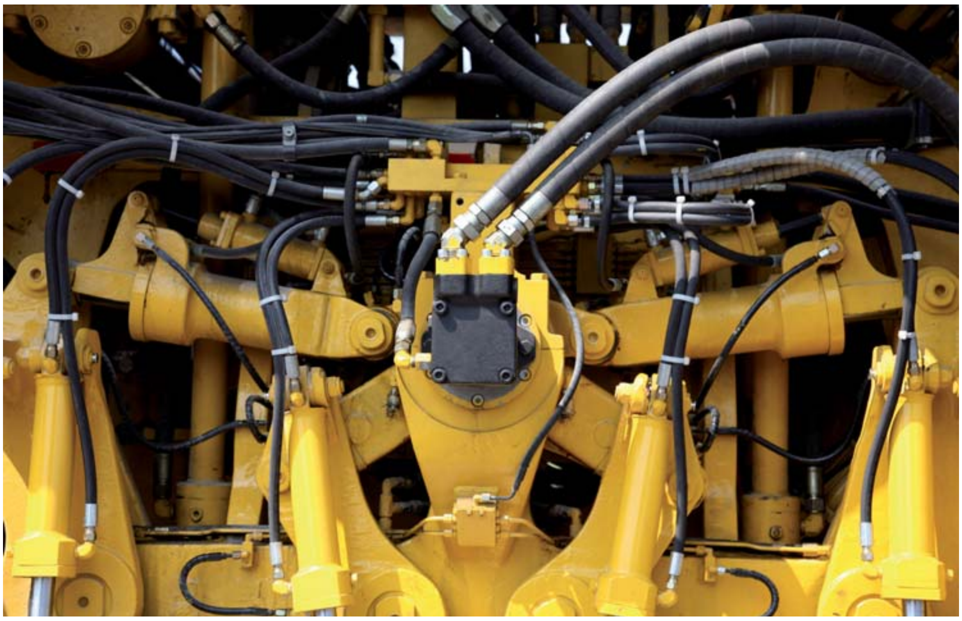
Abstract
The E-HyCON hydraulic drive with two to four CAN interfaces closes a gap in automation systems: It drives highly dynamic multiple axis applications with control cycles of less than 1 ms, while simultaneously controlling pump power with a variable speed drive and using predictive strategies to anticipate demand. The proportion of wasted idle power can thus be significantly reduced for many industrial hydraulic applications, especially where there is a cyclical pattern of transient maximal current requirements.



In an article on trends in fluid technology, Prof. Murrenhoff emphasized that "a huge challenge for the growth of the hydraulics industry will be improving energy efficiency." The further development of individual components, however, will not be a sufficient step, instead it will be far more important to consider the system as a whole. Drive and control technology for hydraulic applications can make an important contribution in this regard. In fact, most hydraulic applications today have a significant gap in automation and signals processing between the pump drive and the process. Depending on the individual load profile, this can lead to considerable power losses. Blanket statements of the saving potential are not possible but experts assume between 50% and 70% depending on the application.

Driving the pump motor based on demand is usually impossible, because the core component of the pumping unit is a constant speed pump that cannot be electronically controlled. A hydraulic loop that "regulates" itself using a pressure-limiting valve is employed in a traditional pumping unit, but with insufficient effect. Once a piston has reached its end position, the pump continues to deliver fluid up to the maximum set pressure. Then the pressure-limiting valve opens and the pump discharges into the tank. The unused volumetric flow Q leads to considerable performance losses in many hydraulic applications.

Particularly during cyclic pauses, with partial loads or in stand-by mode, the required pump power is significantly lower and a traditional hydraulic controller using a pressure-limiting valve is extremely inefficient. Hardly any hydraulic system permanently requires maximum power. From here, a control strategy can be derived that provides pump power as needed, and the result would be an increase in volumetric efficiency and therefore also the total efficiency. The proportion of unnecessary idle power would be reduced.

Demand-controlled pump power

There are currently two major approaches to demand-controlled pump power being explored: power or flow rate controlled axial piston pumps, with either fixed speed or variable speed drives. The fixed speed approach usually involves pumps with controllers tailored to the specific application.

Variable speed pumps on the other hand, have ▷

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Conclusion

The described solution for comprehensive, intelligent automation of hydraulic applications is independent from hydraulic pump manufacturer or drive manufacturer, because it takes over pressure and volumetric flow rate regulation from the machinery host controller. In contrast to the solutions from competitors that implement these functions directly using a frequency converter, this offers a machinery or facility designer more freedom and makes it easier to retrofit it to existing facilities.

The energy efficiency functions are more than just an add-on for controlling hydraulic pumping unit, they bring together the things that from a comprehensive, automation technological standpoint belong together: Hydraulic pumping unit and axis controller.

Just as in human beings, movements and facial expressions are the perfectly coordinated interplay of brain, nerves, blood and muscles, hydraulic cylinders, the muscles of a machine, must be directed and controlled in coordination and supplied with the precise level of energy required. Though this biological comparison may be awkward, the integrated signal processing by brain and nervous system is a vital principle of life to which technology owes many innovations.

References

Prof. Dr.-Ing. Hubertus Murrenhoff (RWTH Aachen): Trends in fluid technology [in June 2011 issue of the "fluid" German magazine] www.mi-verlag.de

Figure 1: The E-HyCON hydraulic drive by Eckelmann with I/O modules and safety module

several key advantages: not only can better value constant pumps be used; but it is also possible to make a more intelligent and more integrated connection between hydraulic power unit and axis controller. The control technology can do far more than just react to hydraulic system parameters like volumetric flow rate or pressure, it can use predictive control strategies to actively match pump power to requirements. The goal of this is to deliver only as much volumetric flow, pressure and therefore also energy from the pressure station, that is actually required for the movement of the axis.

Probably in the next few years the concept of using variable speed pump drives will prevail because of the insight that much greater improvements in energy efficiency can be achieved by considering a hydraulic application as a complete system, that is, from a perspective of control technology that comprises both hydraulic pumping unit and axis controller. In contrast, using pressure or flow-rate controlled pumps means using individual components with the lack of an intelligent higher-level system.

Controller concept

Technically, this can be realized with an integrated system, responsible for drives, pumping unit and axis controller. The E-HyCON controller was specially conceived for hydraulic applications and has the ideal prerequisites. It controls demanding multiple axis applications (up to 64 axes) with a control cycle of less than 1 ms and simultaneously matches flow rate and pressure exactly to requirements. The hydraulic algorithms that have been implemented can take into account special characteristics of different equipment and compensate for nonlinearities, for example. Depending on operational state, the software reacts to slower movements or pauses (stand-by) by reducing speed. If, on the other hand, a fast and sustained movement is expected, the controller can anticipate this, accelerating the pump motor ahead of time to serve the increased demand.

Where multiple pumps are being driven in parallel, on and off sequences can be staggered. The controller dynamically controls the delivery of whatever flow rate is required. This is achieved using variable speed pump drives. It can control the frequency converter.

Adaptive regulation with variable speed pump drives has the energy-saving side-effect of generating less heat and so also reduces the power needed for cooling. Cooling systems can in many cases be downsized.

The controller also monitors and controls the circulating pump in the filtered cooling circuit. As well as the hydraulic-specific monitoring functions for temperature, oil level and filter, it is also well-suited to condition-monitoring of the axis controller.

Figure 2: Hydraulic pumping unit in a steel mill

Experience and simulation

Our long-time experience in automating demanding hydraulic applications has fed into the development of the hydraulic controller. Machine builders can profit from this know-how, in the form of an extensive library of controller building blocks ▷

and technological functions. The application software can be programmed with Codesys in conformation with IEC 611131-3. We advise and assist designers of machinery and facilities with hardware configuration, software programming and successfully bringing systems into service. In contrast with traditional product offerings, we take the responsibility for a complete solution.

Every hydraulic application has unique requirements. In order to find the right control strategy and optimize energy efficient, we also employ modern simulation methods using Matlab/Simulink that yield valuable information starting from the design phase. It also allows designers to predict the system's operational behavior and then compare actual and simulated values so that errors can be recognized as soon as possible.

HMI-design and safety functions

With HMI-design finished visualization building blocks can be accessed. In the accompanying E-Tools VIS visualization package, there are special symbols available for the creation of animated hydraulic schematics. A variety of hydraulic applications with intuitive and appealing user interfaces can be created with little effort.

With its integrated webserver, the hydraulic controller is dynamically accessible with a web browser using HTML, as well as other protocols, for example, XML. This makes it possible to monitor a facility with a PC, a tablet, or a smartphone.

Additionally, the hydraulic control unit provides safety functions with its safety module and is well equipped for the safety requirements demanded by the new Machinery Directive. ◀