Pump control – simple or intelligent?

Control pumps have a fixed place in hydraulics. Your advantage: They only provide as much flow and/or power as is required for the specified movement task. But which pump control is suitable for which application? Mechanical-hydraulic or electro-hydraulic pump control? What are the differences?

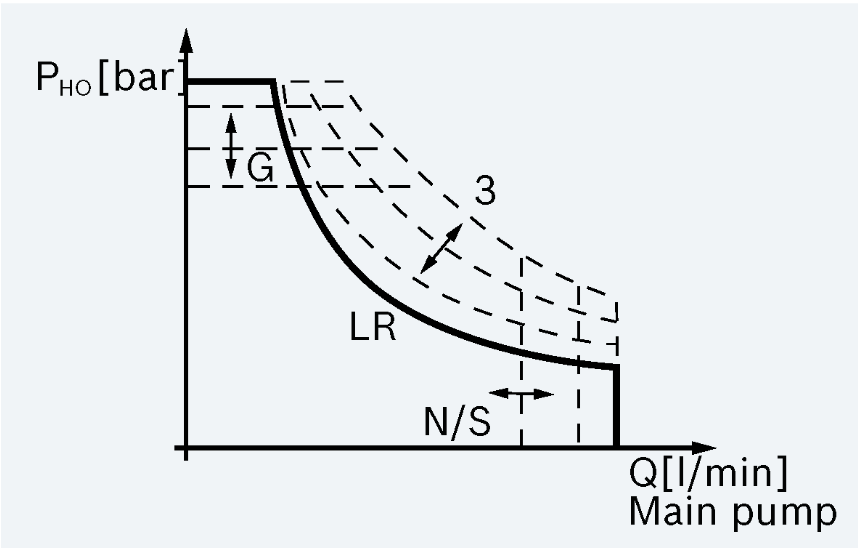

Figure 1: Pump control functions

The advantages and disadvantages of the two pump control types can well be explained using the flow control of a deep drawing press as example. The hydraulic drive of the cylinder is based on a variable displacement pump working in an open circuit.

The displacement is 250 cm3, the nominal pressure 350 bar. The mechanical input signal is hydraulically amplified. In this connection, the pump has three typical control tasks: Flow control (N and/or S function), power control (LR function) and pressure control (G function).

01) Mechanical-hydraulic pump control: simple, however limited

The mechanical input signal from the hand lever is hydraulically amplified. In this case, the flow is controlled by means of load-sensing. The pump swivel angle is adjusted independently of the load occurring at the actuator by means of a load sensing valve which is set to a Δp of 20 bar. So the velocity at the actuator remains constant.

The disadvantage: The throttling of the flow at the pump output goes along with a power loss which is completely converted into heat and increases the cooling demand. One advantage, however, is the easy set-up which does not even require a pilot oil pump as the adjustment energy is taken from the high pressure. Due to the continuous Δp of 20 bar, flow control is also possible at low pressures.

Power controllers increase the complexity

There is a need for an additional pilot oil pump if the deep drawing press – for example for safety-related reasons – requires a flow of zero in case of a low counter pressure (maximum of 4 bar). More components are necessary for realizing the power controller.

02) Electro-hydraulic pump control

Data recording and comparison by control electronics Compared to that, an electro-hydraulic system with only one fast high-response valve at the pump and amending control electronics is the more elegant solution. The regulated variables (path, force and velocity) correspond to the analog hydraulic variables flow and pressure.

The principle: A swivel angle sensor on the actuating piston and a separate and/or attached pressure transducer record the actual flow and pressure values. After comparison to the specified command values, the control performs all flow, pressure and torque limitation tasks and forwards a command value to the valve. Figure 2 shows different pump control systems which are autarkic subsystems and connected to the machine control via corresponding interfaces.

Today, there is a whole range of motion controls and NC controls for hydraulic actuators available. It comprises single-axis controllers without control cabinets where the electronic controls are integrated completely in the valve, up to multiple axis controllers with control cabinets for more complex tasks. In addition, intelligent pump controllers are improving the system performance. These control systems communicate via established field buses or Ethernet protocols with superior systems, and with these open standards it is possible to completely integrate them into Industry 4.0 architectures – this way, intelligent, networkable hydraulics are completely Industry 4.0 ready.

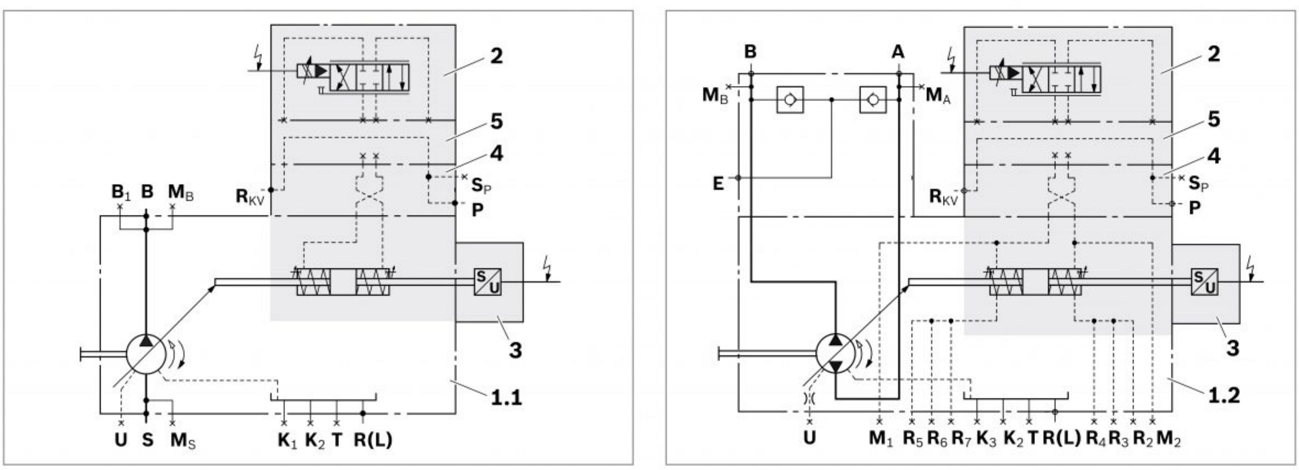

Figure 2: Pump control systems with open circuit (left) and with closed circuit (right)

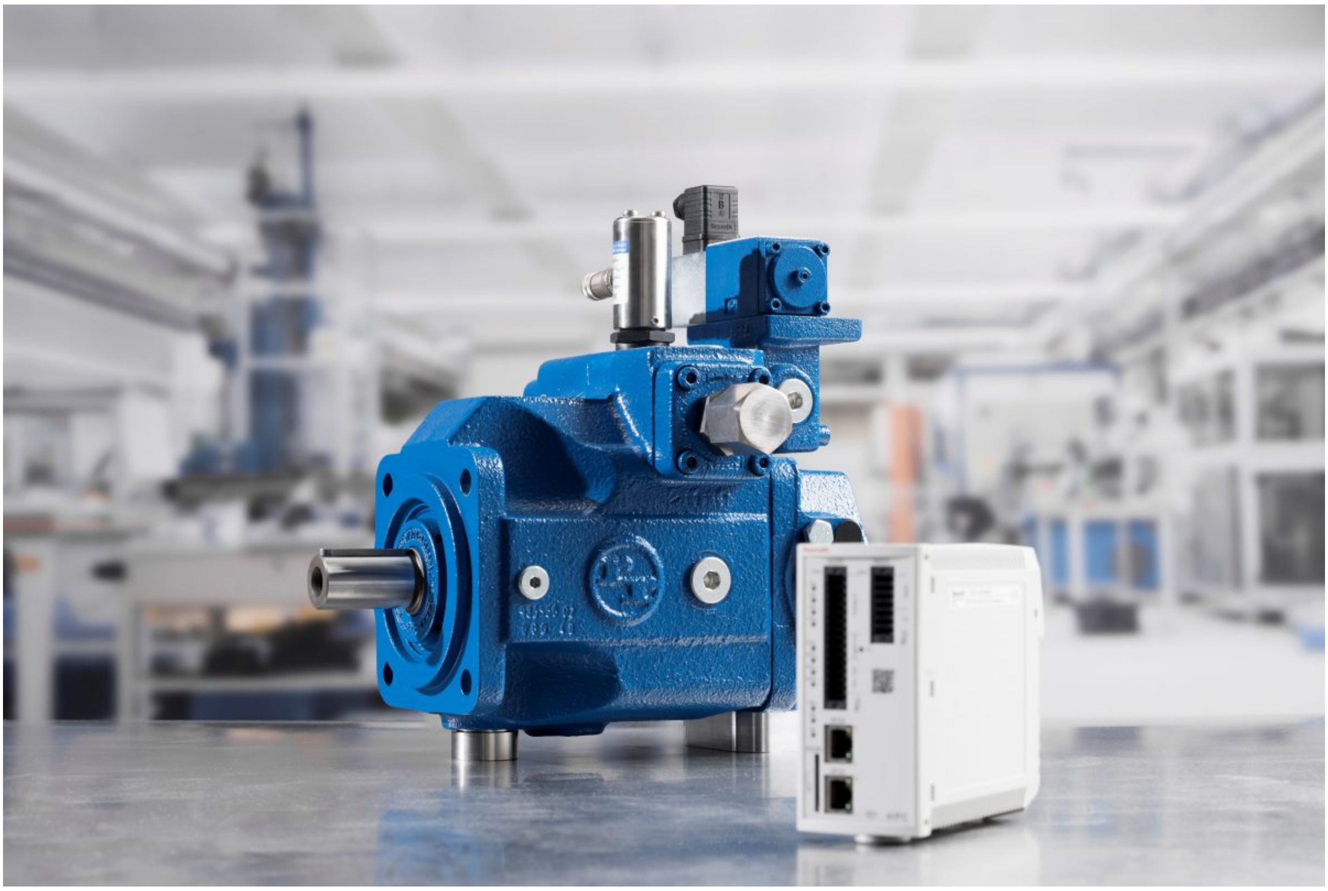

Figure 3: Electro-hydraulic pump control HPC (right) and axial piston pump with HS5 control (left) from Rexroth

03) Decision-making aid: Selection of the pump control type

It first of all depends on the physical variable to be controlled whether the mechanical-hydraulic or the electro-hydraulic variant is finally the better choice for the relevant application. Flow and pressure can be controlled with both types. For limiting the torque, however, the mechanical-hydraulic method needs an additional power controller changing the flow with constant pressure and simultaneously increasing the complexity of the hydraulics. **Here you can find the selction guide**

Master-slave pump combinations

A master-slave pump combination interesting for many applications is only feasible with an electrohydraulic control; however, it allows for combined pump systems with special properties. If, for example, by an early swiveling out of the pump, the master pump provides a certain flow from a certain point in time, it can be positioned at the maximum swivel angle already upon start-up of the motor and deliver into the system, which again increases the velocity and precision of the application.

How dynamic and accurate should the pump be?

The required dynamics and precision are more decision-making criteria. If, for example, particularly high dynamics with up to 80 ms are required, a primarily controlled pump would be suitable. With regard to precision, electro-hydraulic control systems with a repetition accuracy of <= 0.2 % for the pressure and a linearity deviation for the swivel angle of <= 1 % show convincing results. Compared to that, mechanical-hydraulic controls achieve about +/- 1.5% repetition accuracy for the pressure and a linearity tolerance of 2.5 to 7 % of Vgmax. All values are valid for a constant operating temperature of 50°.

Conclusion

The strength of the mechanical-hydraulic pump control is its simplicity. It is, however, only convincing in correspondingly clear applications. With increasing requirements with regard to function, precision and energy efficiency, there is no alternative to electro-hydraulic control systems which allow for pressure and flow control with high control quality according to the demand. As digital control electronics with integrated Multi-Ethernet interface can moreover be integrated into most different structures, it moreover also masters the prerequisites for the increasingly demanded networking in the sense of Industry 4.0.

Question	Electro-hydraulic control systems (onboard or control cabinet-based)	Mechanical-hydraulic control
Which physical variables are to be controlled in the machine?	Flow and pressure, torque limitation, master-slave pump combination	Flow or pressure,
How dynamic should the pump be (e.g. actuating time)?	Fast swivel time, e.g. up to 80 ms (depending on the pump size)	Swivel times 150 to 300 ms (depending on the pump size)
How exact should the control be?	High repetition accuracy (<= 0.2%), very low linearity tolerance, swivel angle <= 1% Values are valid for constant operating temperature of 50°	Repetition accuracy: +/- 1.5% and more), linearity tolerance <= 2.5%, up to 7% of Vgmax Values are valid for constant operating temperature of 50°C
Integration into the control level?	Yes, with Sercos and Multi-Ethernet bus system, or analog integration	No
Does the application require a pump combination?	Yes	No
Pump combination?		
Is the hydraulic circuit offen or closed?	Both possible	Both possible
Compensation of disturbing factors, e.g. leakage oil or temperature?	Yes	No
Should remote diagnosis or remote maintenance be possible?	Yes	No
Know-how regarding the electronic control technology available?	Yes. Simplification of the engineering by means of open technology-spanning engineering environment possible	No

Possible control types	Electronic control onboard	Electron. control, control cabinet-based	Mechanical-hydraulic control
Swivel angle	X	X	X
Pressure	X	X	X
Torque	X	X	X (e.g. by means of power regulator)
Master slave	X	X	-

Info graphics: Decision-making aid for the selection of the pump control type.

You want to learn more about an electro-hydraulic pump control: www.boschrexroth.com/hpc