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Variable-speed drive solutions:

Less current,

less noise, less costs.

Variable-speed drives connect standard components from hydraulic and electric systems to form customized, intelligent and cost-efficient systems. What is the savings potential compared to simple hydraulic solutions, and what should be considered for dimensioning?

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Compared to conventional solutions, variable-speed pump drives save up to

80%

of energy.

The hydraulic drives market is changing. Instead of dimensioning for corner power, machine manufacturers and users are more and more looking for specific and flexible solutions which should be compact, quiet as well as cost-effective and energy-efficient, offer a high degree of safety and which are easy to put into operation. Due to the intelligent interaction of standard hydraulic and electronic components, variable-speed drives meet this complex requirement matrix.

WHAT IS A VARIABLE-SPEED DRIVE?

Variable-speed drives mainly consist of an electric motor, a hydraulic pump and a frequency converter with a software which continuously adjusts the motor speed to the optimal operating point depending on load. Thus the electrically driven constant or variable displacement pump delivers demand-oriented flow in order to control pressure, speed, power, position or force, depending on the task. The wide range of applications includes machine tools, wood and paper processing machines as well as metallurgy applications and molding presses, die casting machines and injection molding machines.

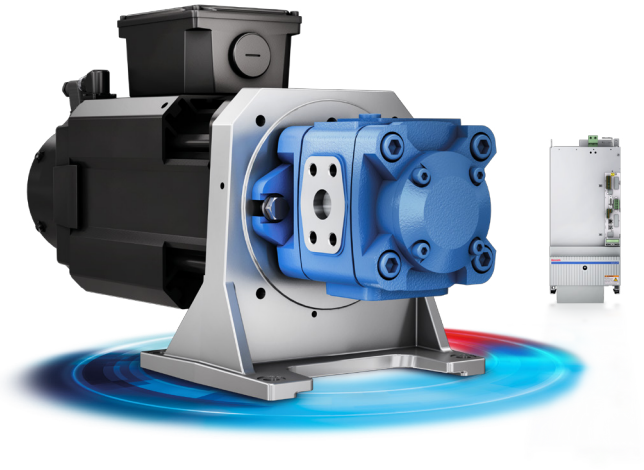
THIS IS HOW THE VARIABLE SPEED INCREASES EFFICIENCY

Variable-speed drives are the solution for the typical problems of conventional hydraulic drives. Pressure is no longer limited by proportional valves but controlled by speed. Thus design-related pressure losses are eliminated. Moreover, electric losses in the motor as well as hydraulic losses in the pump are reduced by using a frequency converter which disconnects the motor from the mains frequency. Due to the frequency-dependent speed adjustment, the required pressure can now also be ensured for minimum speeds. Thus, it is also possible to operate variable displacement pumps with minimum speeds which results in further efficiency increase. Furthermore, the automatic pressure-holding operation reduces the delivery volume just to an extent that no hydraulic oil has to be discharged through the pressure relief valve. This is in particular interesting for clamping applications which only require low flow.

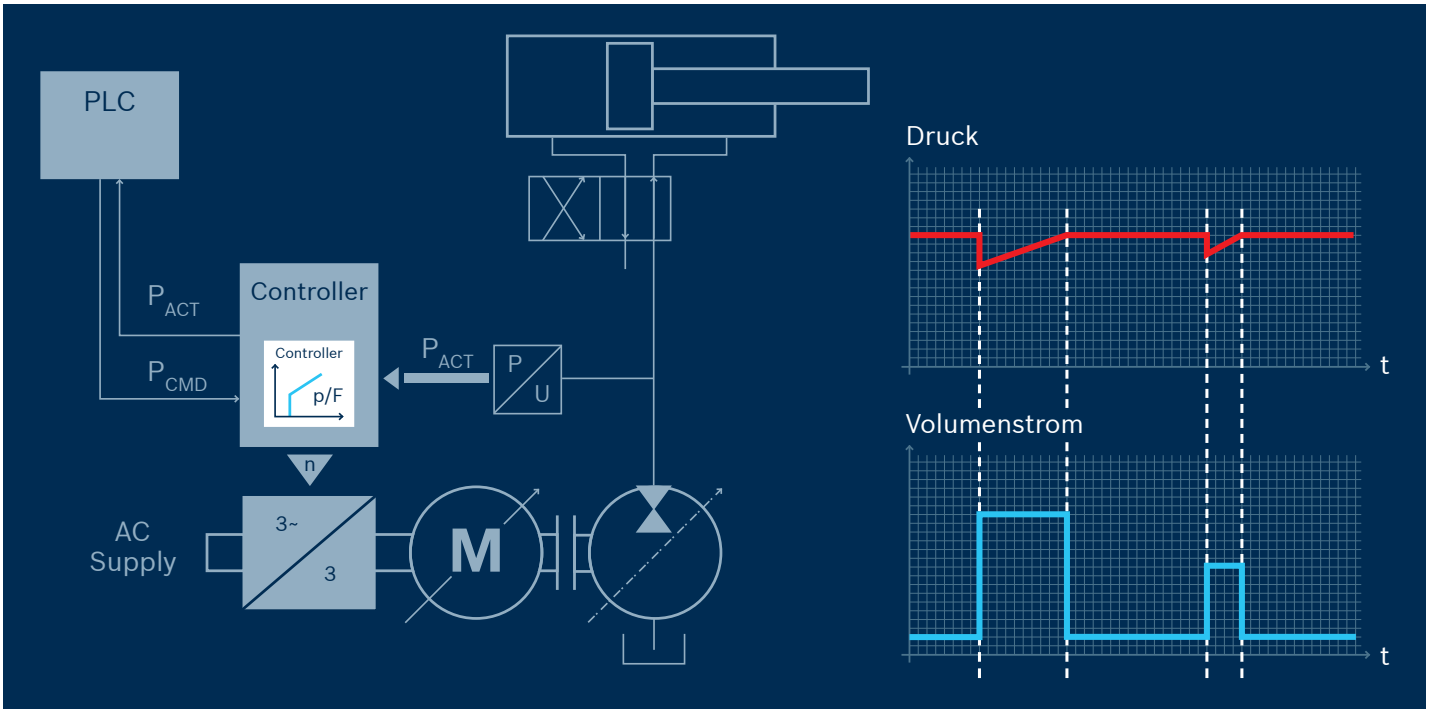
FUNCTIONAL PRINCIPLE AND DESIGNS

When using a variable displacement pump, the flow capacity of the system can be calculated from the speed of the electric motor and the adjustment of the pump. During operation, the machine control transfers the command values for pressure and flow to the frequency converter. A pressure sensor measures the current system pressure and transfers it to the drive. On the basis of the control deviation, an integrated PID controller calculates the required motor speed dynamically adjusting it to the existing system requirements for flow and pressure. Thus, the swivel angle of the variable displacement pump is always maintained at the ideal operating point in favor of pump efficiency.

For high dynamic requirements as well as force, speed and position controls, the asynchronous motor is replaced by a servo motor with appropriate controller, and the variable displacement pump is replaced by a displacement pump. Servo-variable pump drives are primarily used for injection molding machines.



▲ **State-of-the-art variable-speed drives provide the intelligent interaction of electric motor, pump and frequency converter.**



▲ **Block diagram and characteristics of a variable-speed drive for constant pressure systems.**

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ENERGY SAVINGS OF UP TO 80 PERCENT

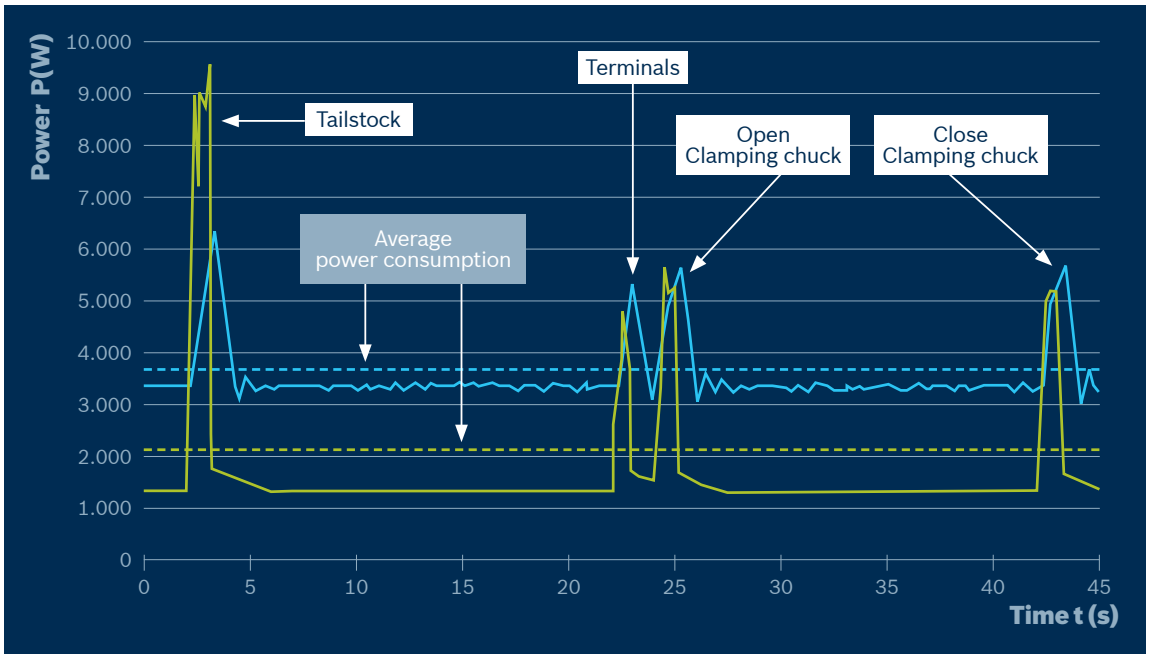
Variable-speed pump drives do not just reduce electric losses in the motor but also frictional losses in the motor and the pump. Thus they are in the position to reduce energy requirements by up to 80 percent compared to simple hydraulic systems. This applies in particular to servo motors with permanent magnet as well as sleep/wake function which switches off the motor in favor of energy efficiency. The consumption-related CO2 emissions are reduced analogously to the power consumption. And finally the operating costs are reduced by energy efficiency. Except for the continuous operation with constant load, this is beneficial to all application scenarios: to short-time operation as well as to periodic operation with and without interruption, with individual constant loads as well as load or speed changes.

Type	Constant drive with mechanical p/Q adjustment (classical)	Variable-speed drive with frequency converter	Variable-speed servo drive with servo controller
Control	Pressure / flow (p/Q valve)	Pressure / flow	Pressure / flow Force / position
Motor	Asynchronous motor with constant speed	Asynchronous motor with **variable** speed	Servo motor with **variable** speed
Pump	Variable displacement pump	Constant or variable displacement pump	Displacement pump
Energy savings	By avoiding proportional valves / pressure relief valves	With variable displacement pump and by reducing speed in the partial load range	Up to 80% due to speed reduction in partial load operation and highly efficient motors
Advantages / disadvantages	+ cost-effective solution – low dynamics – high losses – high noise emission	+ low-noise + energy-efficient + condition monitoring – low dynamics	+ high dynamics (low moment of inertia of motor) + high energy efficiency + condition monitoring – high price
Appli-cations	Central pressure supply for systems with power distribution	Machine tools, Wood and paper industry	Force, speed and position control in presses, die casting and injection molding machines

▲ **Drive types with constant and variable motor speed – with constant and variable displacement pump.**

REDUCTION OF NOISE EMISSIONS BY UP TO 20 DB (A)

Variable-speed drives further help comply with the noise emission provisions according to EU directive 2003/10/EC. They are reduced by up to 20 dB (A) compared to conventional hydraulic power units because the lower the speed, the lower the sound level. This effect can be well utilized with an axial piston pump since it allows for the implementation of speeds down to zero. Internal gear pumps generally have a lower structure-borne sound emission.



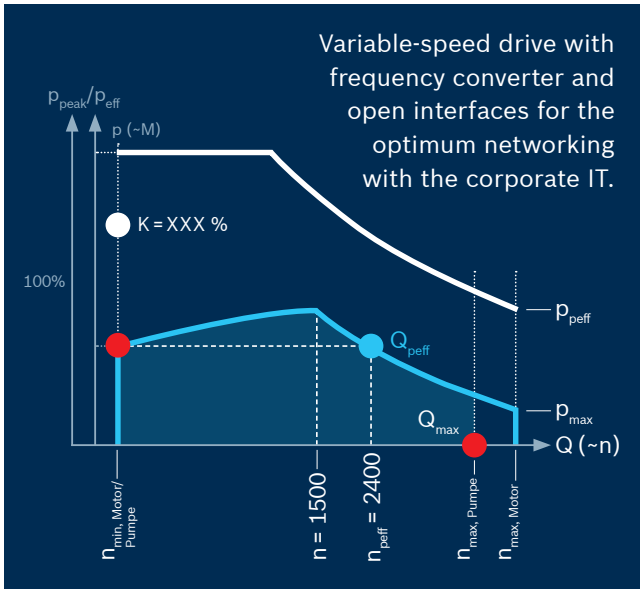
Current power consumption
- Accumulator charging circuits
- SYTRONIX

Average power consumption
- Accumulator charging circuits
- SYTRONIX

Load profile in a machine tool. The difference between the average power consumption shows the savings potential for the variable-speed pump drive.

REDUCED INSTALLATION SPACE

Due to their compact design, variable-speed drives in general require far less space than conventional hydraulic systems. Due to the simplified valve technology and the resulting reduced requirements, less control electronics are needed, and due to the highly dynamic control, the hydraulic accumulator can also be reduced. In many cases, the electric motor can have smaller dimensions in favor of the integration capacity in the systems and machines. Due to the resulting reduced heat input into the hydraulic fluid, the cooling system required to this end can also be reduced or even omitted. However, an exact design is required for this purpose which fully utilizes the overload range of the system.



INVESTMENT COSTS AND SYSTEM LIMITS

The key for limiting investment costs lies in the demand-oriented performance provision – not only for the cooling system and the electric motor but also for the pump, fluid tank and sound insulation. In order to find a solution which is optimal in terms of every aspect, a total of eleven system limits must be fathomed using manufacturer-specific software tools such as SytronixSize by Bosch Rexroth. They include the maximum and continuous torque of the motor dependent on the converter, the minimum and maximum speed of the motor and the pump and continuous pressure and temporary overload range. Furthermore, the power limitation of the pump, the dynamics until the end of the speed range as well as the cooling type and corner frequency of the motor must be taken into account. Another important factor are the energy efficiency provisions according to EU directive [EC] 640/2009.

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ENGINEERING, INSTALLATION AND OPERATIONAL SAFETY

Further advantages compared to conventional drives are derived from the intelligent control. Switchable pressure and flow command values result in faster project planning times. This is also applicable if several command values can be saved, selected or specified by means of field bus communication. Other advantages are the practical functions such as the accumulator charging operation or the hydraulic soft start which extends the life cycle of the system by smoothly starting the motor. Status monitoring and diagnosis as well as an integrated system design with proven standard components increase availability and operational safety. Pre-configured solutions with matching standard components ensure simplified installation. Thus, even complex pump drive systems can be quickly commissioned. Last not least, intelligent control systems allow for the integration into predictive maintenance concepts.

CONCLUSION

Variable-speed drives have a high optimization potential for hydraulic systems. Due to the intelligent interaction of standard components, they combine the reliability and force of the hydraulic system with the energy efficiency and dynamics of electronic drives and systems in order to find the optimum electro-hydraulic solution for each application. Supported by the software-driven design, not only the total cost of ownership can be reduced but also further current requirements may be met – from lower noise emissions and space savings to Industry 4.0 applications such as condition monitoring and predictive maintenance.

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