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By **Kenneth Kauppila**
Senior Project Engineer
Moog Inc.
East Aurora, N.Y.

An injection of innovation

Hybrid drive unit overcomes limitations of electrics, hydraulics by capitalizing on their advantages for injection molding.

Injection molding machines powered by electric drives have become more and more prevalent in the past several years. In many cases, machines with hydraulic drives stood their ground until an all-electric machine became feasible. Consequently, machines that years ago were considered impractical or cost prohibitive for electric drives have become a reality. In fact, some machine builders are contemplating designing electric machines with clamping forces as high as 2,000 tons. But applying technology that reduces or eliminates the disadvantages of hydraulic drives may allow them to stave off the competition from electric drives.

For applications requiring high force and high speed, manufacturers have been unable to build an all-electric system that matches the performance of units powered by hydraulics. In these cases, a hybrid approach using both electric and hydraulic technologies in an integrated system may be the preferred option. So instead of competing with each other, these two systems work side-by-side to provide the best combination of characteristics.

One solution to this challenge is the PowerShot Injection System. This system combines the speed, force, and compact size of an accumulator-based hydraulic system with the modularity, quiet operation, and cleanliness normally associated with electric systems.

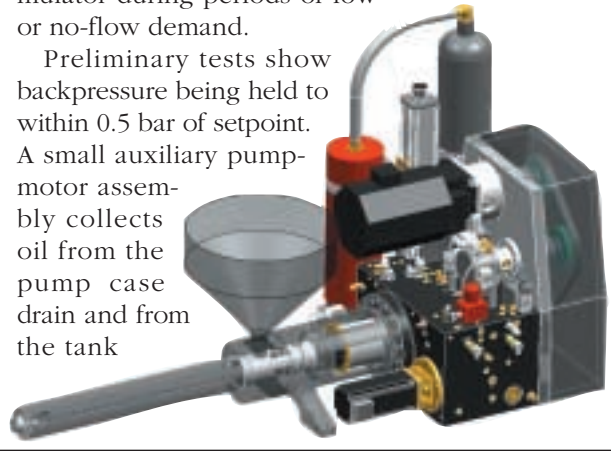
Defining the concept

The PowerShot uses an accumulator and a Moog SE3 servocartridge valve with a step response time of 15 ms to provide closed-loop control of velocity, pressure, and position of the plasticizing screw. Injection speeds of 1 m/sec (39.4 in./sec) and plastic material pressures of 3,000 bar (43,500 psi) are possible with this system.

A single Moog FAS series servomotor and planetary gear speed reducer provide closed-loop rotational speed control of the plasticizing screw. A helical belt and pulley system connects the servomotor to the speed reducer to provide additional speed reduction.

The main servomotor also controls a Moog RKP radial-piston pump, which is used for closed-loop backpressure control during the plasticizing portion of the cycle. This pump also provides the flow to recharge the accumulator during periods of low- or no-flow demand.

Preliminary tests show backpressure being held to within 0.5 bar of setpoint. A small auxiliary pump-motor assembly collects oil from the pump case drain and from the tank



ports of the hydraulic valves, and returns it to the accumulator for the next cycle. To improve the overall energy efficiency of the system, both servomotors are turned on only as necessary during the cycle.

Even though this is a sealed system, with little opportunity for contamination to enter the system, a filter maintains proper fluid cleanliness. A small brazed plate heat exchanger maintains a constant oil temperature.

Unconventional hydraulics

The PowerShot Injection System is a sealed, closed-loop hydraulic system, with many benefits when compared to a traditional hydraulic system. A typical hydraulic power unit (HPU) found on an injection molding machine is made up of at least one electric motor, pump, pump manifold, and heat exchanger, as well as a reservoir, which typically would range in size from 100 to 1,200 gal, depending on the size of the machine. A large accumulator manifold assembly is also used on high-speed versions of these machines, and an injection manifold is required to run the injection unit. All of these components must be piped together with a variety of hoses, fittings, and brackets. They are mounted on the machine base and covered with a sound reduction system, which includes access doors for the components.

Components on the PowerShot are connected by cross-drilled holes in a single manifold, with O-rings at the connection points — drastically reducing the potential for leaks, while reducing machine assembly time and maintenance issues.

In addition, by mounting all components on a single manifold, pressure drop losses in the system are drastically reduced. The components are separated by centimeters, not meters as in a conventional system. For every 90° turn in a hydraulic system and every hose, pipe length, or fitting used to connect the components, there is a quantifiable pressure drop. Because no external HPU is required, the customer can also simplify their base design and reduce the floorspace required for the machine.

The system is also cost effective for companies to install and operate in the plant. Being a sealed system, there is little opportunity for contamination to enter the hydraulic fluid. Because contamination is one of the leading causes of premature hydraulic component failure, the longevity and reliability of the hydraulic components are improved. Other benefits include modularity and ease of installation. This unit is designed with few connection points to the machine, so it is quick and easy to install.

> “For every 90° turn in a hydraulic system and every hose, pipe length, or fitting used to connect the components, there is a quantifiable pressure drop.”

The PowerShot uses long-lasting synthetic hydraulic oil, which is biodegradable and virtually nontoxic — addressing customers' environmental and part contamination concerns. The smallest system only requires 16 liters of oil, far less than a typical hydraulic system.

The system features improved energy efficiency, because the main servomotor and pump run only during the recovery (plasticizing) portion of the cycle. A typical hydraulic system would have the electric motor and pump running continuously, with the variable pumps destroked during idle periods.

Comparison to electrics

In an all-electric injection unit, once the maximum pressure has been reached in the mold, the system quickly reduces the pressure to approximately half in 0.02 sec to avoid flashing the mold. This pressure must then be held while the part cures.

Hydraulic systems have an advantage over all-electric systems in pressure control. Large parts require long hold periods, which can cause problems for servomotors in all-electric machines. To hold the force, servomotors must be in a stalled condition for long periods, which can lead to overheating. By contrast, the PowerShot needs only to modulate the spool in the servocartridge to control pressure, thereby improving energy efficiency.

In general-purpose injection molding applications, multiple servomotors and ballscrews are the most common design used for

the injection unit in all-electric machines. This design is not possible in high-speed applications, where high forces and high speeds are required. As speed and force requirements increase, the amount of installed power required and the associated cost of the components increase far more rapidly for an all-electric assembly than for an equivalent hydraulic system.

In some applications, the cost of an all-electric system can be 30% more than a similar hydraulic system. And in large, or demanding, applications it simply is not possible to build an all-electric system to meet requirements, because inertia of the motors prevents reaching the required acceleration or deceleration.

The control system

Controlling the PowerShot is the Moog Servo Controller (MSC), a flexible, freely programmable multi-axis controller with integrated PLC functionality. The MSC communicates with the existing machine controller using digital I/O signals and/or serial communication. A control structure where the existing machine controller supplies analog command signals to the MSC can also be accommodated. The MSC can display all these process parameters on the existing machine controller. The parameters and current cycle data can then be downloaded to the MSC using a serial communication line. Display of current injection speed, pressure, and other key parameters are easily monitored. This allows for a tight integration between the existing machine controller and the PowerShot Injection System, as no additional display is needed.

Summary

The design of the PowerShot Injection System allows it to be scalable to a wide range of machine requirements while offering the benefits of both hydraulic and electric technologies. The system is currently being considered for machines as small as 250 tons, and as large as 4,000 tons. The system offers superior velocity, pressure, and position control, in an energy efficient package. With few connection points to the machine, it offers quick and easy installation. ■

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For more information, please contact:

Moog Inc.
Industrial Controls Division (USA)
telephone: +1-888-551-MOOG(+1-716-687-4954)
fax: +1-716-655-1803
e-mail: sales.icd_hyd@moog.com
website: www.moog.com/industrial