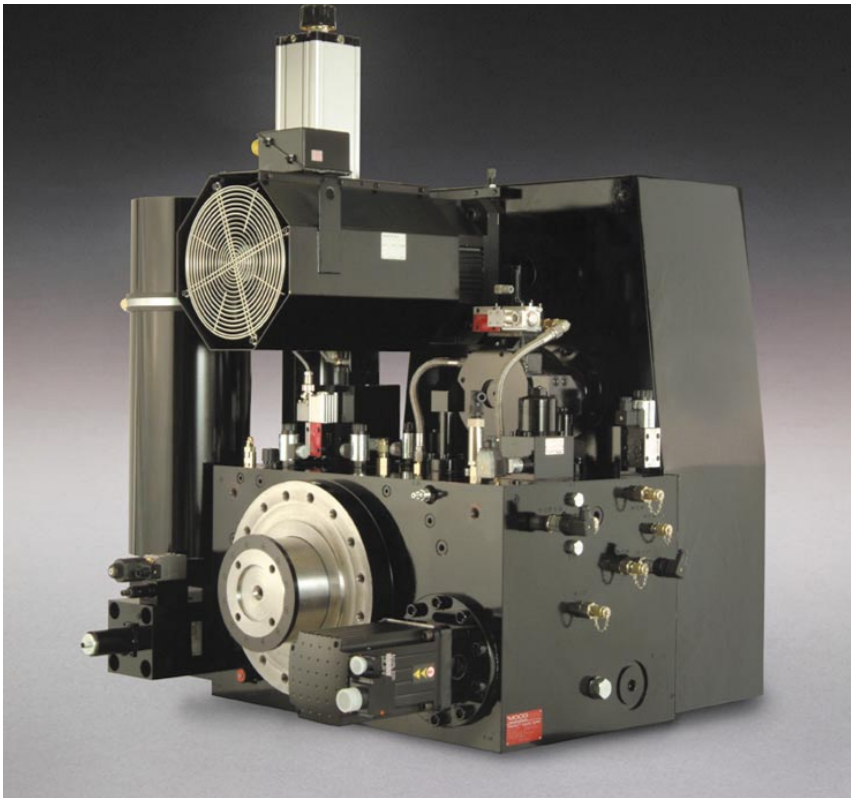
design news



BIG SHOT: **Moog's PowerShot is a sealed hydraulic injection unit that targets molding machines whose size and speed rule out injection units driven by electric motors or traditional hydraulics.**

ELECTRO-HYDRAULIC ACTUATOR

Rethinking Molding Machine Hydraulics

When size is considered, big molding machines may represent a worst-case scenario for electric motors

Like machine tools before them, injection-molding machines started going electric more than a decade ago as some of their builders jumped at the chance to improve energy efficiency, repeatability, reliability, and even cleanliness by replacing hydraulic drives with electric ones. And electric motors have delivered on these promises when it comes to small- and medium-sized molding machines. But they haven't done as much for the largest, fastest molding machines. Blame physics. "The problem is inertia," says David Geiger, industrial systems engineering manager for Moog Inc. (www.moog.com), a maker of electro-hydraulic components and controls.

Why is inertia such a big deal? Shooting plastic into the mold requires the machine's screw to act as a ram, darting forward quickly and then stopping on a dime. In the most demanding molding applications, Geiger reports, the screw could travel as fast as 1.2 meters/second, accelerating and decelerating in 20 milliseconds or less. To move the screw that fast, the motor that handles linear motion has to spin up quickly while devoting a portion of its torque to overcoming rotor inertia. In smaller machines— those with less than 500 tons of clamping force—the electric motors can easily be sized with enough torque to handle both rotor inertia and the plastic injection tasks.

But Geiger argues that larger machines, which have motors as large as 100 HP, present a different story. "The electric motors on large machines are so big they act like giant flywheels," he says. "It takes a huge amount of energy to get them going." He estimates that on large high-performance machines—like the ones used for many automotive parts and high-speed packaging—at least 85% of the motor's available torque is devoted to beating inertia. "Only 15% goes toward accelerating and decelerating the screw," he says. "It's a huge waste of power."

And this inertia problem in the end can affect molding performance by throwing off the injection cycle's crucial "switchover" between the screw's forward movement and a holding mode that helps pack out the part. Electric machines have historically done a very consistent job at holding the screw in that forward position, Geiger acknowledges. But in the moments leading up to the switchover, they tend to suffer from what Geiger describes as a braking problem. "If molding machines were little robots or the screw needed to decelerate in 150 milliseconds, it would be a piece of cake for electric motors," he says. But molding machines in question are nothing if not big and fast. "So how do you get that massive rotor moving at 1,800 rpm to come to a complete stop in 10 to 20 milliseconds?" he asks. And inconsistent switchover can carry a stiff penalty in the form of an unrepeatable molding process.

With no massive motor parts to spin up at the start of the injection cycle, fluid power systems don't suffer as much from iner-

tia, according to Geiger. But traditional hydraulic injection units do have an important performance disadvantage compared to their electric counterparts. Electrics do a very good job at controlling the pressure behind the screw. This "backpressure" control contributes to a consistent injection cycle and, ultimately, part-to-part consistency. "Electric machines do a great job on backpressure control," he says.

In an effort to get the best of both electric and hydraulic injection, Moog recently developed a patented electro-hydraulic actuator called PowerShot. Unlike traditional hydraulic injection units, PowerShot has no separate power unit consisting of a gear motor and a holding tank for the hydraulic fluid. Instead its oil circulates in a sealed, closed loop. Driven by an integrated accumulator, PowerShot controls injection pressure and velocity with a servo-proportional valve. A rotary pump completes the system, performing the important tasks of regulating backpressure and returning the oil to the accumulator between shots. "A key difference between PowerShot and traditional injection units is that we keep all the oil under pressure all of the time," says Geiger.

DATA

400

Number of fluid power manufacturers in the U.S.

Source: NFPA

This sealed arrangement promises some compelling advantages. For one, Geiger says, it improves efficiency—because oil in a closed, pressurized system stays in a higher energy state. What's more, a sealed hydraulic system doesn't need extra energy input to maintain force during the hold cycle, whereas an electric machine needs to keep drawing current.

Because of these factors, Geiger places PowerShot's efficiency at more than 80% in terms of power in to the injection unit to power out through the entire cycle. By contrast, he estimates that the largest, fastest electric injection units often have efficiencies less than 20%, despite their reputation for the overall operating efficiency of small all-electric machines. "I know a lot of molders would think that's a bunch of bull," he says. But he stands by his calculations, stressing again that the inertia problem chips away at efficiency of the injection unit as motor size increases—as the mismatch between load and motor inertia grows.

Another advantage from the sealed oil relates to backpressure control. Geiger gives PowerShot's backpressure control at ±0.2 bar, on par with electric machines and much better than the ±1 bar typical of traditional hydraulic injection units. Finally, PowerShot would simplify molding machine design. This compact assembly not only saves the bulky power unit but also all the related manifolds and hoses.

SO HOW DO YOU GET THAT MASSIVE MOTOR MOVING AT 1,800 RPM TO COME TO A COMPLETE STOP IN 10 TO 20 MILLISECONDS?

Geiger expects its cost will settle somewhere between traditional hydraulic injection units and more expensive electric ones. "Our intention was to offer a high-performance option that costs less than an all-electric," he says. So far, no machine makers have adopted PowerShot in a commercial product. But Geiger notes that an important Japanese supplier of large all-electric and hydraulic machines, had the system on display at the last International Plastics Fair held in Japan. *—Joseph Ogando*