Hydraulic Presses: Smooth Operators

Stampers should appreciate the evolution in closed-loop redundant controls and in proportional valves, manifolds and other hydraulic components. Whether through retrofit or as a new buy, today's presses are graceful metalformers.

by Brad F. Kuvin, Editor

A 125-ton Greenerd hydraulic press works in the FCI electrical-connector plant in Lincoln, NH. The press is one of three hydraulic presses used to flatten, pierce, mark and trim lugs from copper-tube blanks.

To steal a line from songbird Sade: Today's hydraulic presses truly are smooth operators. Fast closed-loop controls monitor and adjust valve activity every few milliseconds, so that state-of-the-art valves precisely control and direct hydraulic oil to the press. Add in the increased use of finite-element-analysis (FEA) software for press-frame design, to accurately simulate press characteristics such as deflection under load, and users of hydraulic presses have it made.

Hydraulic presses always offered tremendous advantages to metalformers in terms of flexibility and control of ram speed and stroke. Now they have it all in a much more maintenance-free package, more affordably and safer, and with a higher level of control and precision.

"More and more, hydraulic presses are incorporated into assembly cells or into automation production lines," says Tom Wendel, engineering manager for hydraulic-press builder Greenerd Press & Machine Co., Nashua, NH. "Our customers expect us to predict exactly what will happen to a press under load. Thanks to FEA, we can simulate load conditions and visually identify load conditions throughout the frame."

Improved confidence in frame design enables hydraulic-press builders to reduce costs to press buyers—in many cases, metalformers have been able to purchase a beefed-up C-frame press rather than a more expensive four-post press.

Energy Savings

Also easier on the press buyer is the ability of press manufacturers to integrate smaller motors than in previous press designs, and still deliver the necessary amount of horsepower. Another plus: smaller motors and other press-technology enhancements deliver significant energy savings to metalformers.

"Thanks to improved prefill valves and other system components," says Tom Lavoie, Greenerd applications manager, "a 75-hp motor can deliver the press performance that once might have required a 200-hp motor. Couple this with the ability to downsize the pump and provide increased strokes per minute and the overall performance improvement of hydraulic presses becomes significant."

Another energy saver is increased use of variable-displacement axial-piston (high-pressure) pumps rather than fixed-displacement vane (low-pressure) pumps, according to Jeff

Grube, manager, press group, Bosch Rexroth Corp. "Axial-piston pumps," Grube says, "deliver more power from the motor to the pump or press, and ultimately to the workpiece, rather than blowing oil across valves and wasting energy by dumping it back into the reservoir. Also, since an axial-piston pump builds greater pressure, the press builder can employ smaller cylinders and piping and specify a smaller reservoir and filtration system, downsizing the overall package."

Axial-piston pumps perform at efficiencies as great as 93 percent, says Grube. "We do a lot of retrofits with axial-piston pumps, and metalformers immediately see advantages in energy savings, increased pressure capabilities and reduced cycle times."

One more energy saver, according to David Sullivan, press product manager, Rockwell Automation, is use of variable-frequency drives. "These are special types of motor controllers," says Sullivan, "that vary the speed of the motor. For example, you don't need high motor speed and power during the dwell time of a hydraulic-press cycle. A motor rotating at lower speeds uses less electrical energy because less torque is required to rotate the motor shaft driving the hydraulic pump. These motors find use on hydraulic presses forming parts that require long dwell times with the ram closed."

Flexibility Redefined

The ability of a hydraulic press to have the ram approach a part quickly, then vary speed during the forming process and again retract quickly gives metalformers flexibility in part and process design. But from an end-user perspective, that's just the tip of the flexibility iceberg.

"Those who specify hydraulic presses and systems have more components and capabilities to choose from than ever before," says Grube. "For example, valve manufacturers offer complete lines of valves that allow us to place a valve in a circuit that exactly matches the requirements of the press, so that the metalformer need not buy more than is needed. We match the component to the performance required."

Valve cost has dropped dramatically recently, with improvements in proportional-valve design enabling suppliers to offer them as replacements for more-expensive servo valves used in hydraulic-press circuits. These advances in valve design as well as in controls have eased the integration of these elements into presses. "Over the last three to four years," says Greenerd's Wendel, "we've seen a dramatic cost reduction in some components—we can still achieve accuracies of ±0.001 in., with significantly less electronics and valving. With the programmable-logic controllers (PLCs) and interfaces available today and sophisticated proportional valves and linear transducers, press builders can deliver more capabilities for less money."

Better Control Elevates Press Performance

The improved performance of proportional valves gives hydraulic-press users control over the net force

Dial Presses Automate Terminal Production

At the Framatome Connectors USA, Inc. (FCI), plant in Lincoln, NH, a trio of hydraulic presses stamps out 150 different parts in lots to 30,000 per run, at rates to 2000 per hour. The plant manufactures electrical connectors—lugs and splices used in power-transmission applications. Lugs are round on one end, flat on the other; splices are flat on both ends, ideal for production on mechanical presses. The hydraulic presses turn out the majority of the lugs made here—the flexibility of the hydraulic presses, coupled with state-of-the-art tooling, enables the plant to quickly adapt the presses to a new part with a 15-min. changeover.

Copper-tube blanks (left) at FCI turn into electrical-connector lugs, right, via automated stamping in hydraulic presses. The press cycle is flatten, pierce (the hole), skive (the slot), mark and trim.

"Up until 1989, we used only mechanical presses here," shares Earle Temple, FCI manufacturing engineer. "With our first hydraulic press, purchased in 1989, we immediately saw benefits from being able to adjust the tonnage from job to job." Now the shop operates three hydraulic presses, all from Greenerd Press, Nashua, NH. The original press was a 100-ton model. The plant purchased a 125-ton press in 1999 and a 150-ton press in 2001.

The production cycle for the lugs processed in the hydraulic presses goes like this: copper-alloy tube, to 1.5 in. OD with wall thickness to ⅛ in., is cut to length by saws. Then the blanks load manually into the dial tooling. As the tooling locates a blank under the press ram, it is flattened at one end, pierced, marked and trimmed to final length.

To stamp the lugs, Temple says that the biggest challenge is dealing with inconsistent tube concentricity. To flatten the end might require extra tonnage from one tube lot to another—this is where the ability to easily adjust press tonnage offers significant benefits, he says. "Because of the complexity and variation in design of the lugs produced here at our facility, changeovers using mechanical presses used to take two or three days," Temple recalls.

"We tried to automate the mechanical presses, but the limited flexibility of those presses made for complicated fixtures and lengthy production delays during changeovers. The flexibility of the hydraulic presses led to simpler fixturing and dramatically quicker setups," says Temple.

applied to the ram through the stroke. Thanks to transducers and sensors, metalformers gain control over ram position. All of this detailed information about the press cycle—ram position and speed—must be digested quickly and fed back to the valves and transducers in a feedback loop quickly enough to allow a stamper to meet increased cycle rates, while ensuring the press runs smoothly. The onus for monitoring press data and signaling the fine adjustments, in a quickly closed control loop, falls on the PLC.

"Today's PLCs close the loop 10 times faster than previous controls. This results in greater precision during forming and greater control of the forming process, with a smoother speed/position profile that minimizes press shock and vibration. We can ramp the control signal being sent to the hydraulic valves and create gradual changes in hydraulic-oil flow rate. You get less hammering and shock to the piping and cylinders during acceleration and deceleration. Less vibration means less wear and tear on the machine, its components and the dies, and less leaks and downtime."

The evolution in press controls couples with improvements in valves to dramatically increase forming accuracy. "We see users of hydraulic presses meeting tolerances of 0.001 in. or better, compared to 0.01 in. just a few years ago," shares Sullivan. The resulting smoother profile also has allowed press users to stamp faster.

"Typically, when you make something operate smoother and more accurately, you can increase the speed," continues Sullivan. "More reliable control allows us to make process changes more quickly, so what might have been, using previous control technology, a step response between speed changes becomes a smooth response because we have improved control over the machine's inertia and momentum. We're seeing speed increases of 10 percent in the marketplace."

Reliable Components Equate to Reliable Presses

Let's face it—in the past, hydraulic presses didn't exactly show up in the dictionary under the word "reliable." But today, leaks, malfunctioning valves and faulty electrical circuits are few and far between.

"System complexity has been greatly reduced in recent years," says Bosch Rexroth's Grube. "For example, a circuit designed with two pumps—a high-pressure low-flow pump for forming and a low-pressure high-flow pump for rapid advance and retract—now can be replaced with a single variable-displacement axial-piston pump. One pump means a simpler circuit."

"System complexity has been greatly reduced in recent years,"

says Bosch Rexroth's Grube.

New valve designs with on-board electronics make for simpler electrical circuits, too. "Five years ago, the valve industry ramped up production of proportional valves with on-board electronics," says Grube. "In the past, you needed an amplifier card as an interface between the controller and the valve. Now we can build the amplifier right onto the valve itself—one less component to worry about. This also makes it easier for the end user to control the valves with any controller on the market."

With on-board electronics comes self-diagnostic capability for the valves, via a controller network such as DeviceNet or Profibus. This carries not only control signals but also information to help shops configure and troubleshoot sensors and devices on the network. Rather than climb on top of a press to investigate a component failure, a maintenance person can access the PLC over the network and check on the health status of every component in the circuit, quickening machine diagnosis and minimizing press downtime following a component failure.

"Built-in amplifiers on valves and their self-diagnostic capabilities," says Greenerd's Wendel, "eliminate the possibility of one of the connections being lost, and allow press builders to ease maintenance concerns for the stamper. And, from the press-control perspective, we can offer this capability—more control with improved reliability—at a significantly lower cost. In 1998, a valve-control package that might have cost $35,000 can be purchased today for $10,000 to $15,000, without the need for special amplifier cards or special software to communicate to the PLC."

Scalable Technology

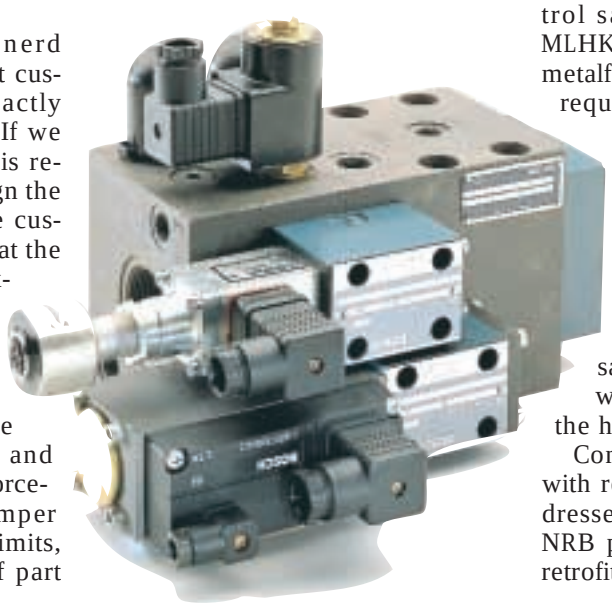
Hydraulic-press builders have so many valve and control options available to them now that they can customize press capabilities to meet specific needs of customers. And, since control technology is scalable, according to Rockwell's Sullivan, the stamper easily can upgrade its hydraulic system down the road as needs change.

"You now can build a press-control system using modules that offer consistency over the entire range of press sizes and application requirements," says Sullivan. "Later, the controls can be upgraded by adding or subtracting modules. It's not a one-size-fits-all scenario. We can design the right amount of technology for each application. We have to be careful not to sell stampers what we think they need—suppliers need to listen to the unique needs of each customer and sell them the right amount of technology to do the job."

Grube and Bosch Rexroth say the same—with more valve choices today than ever before, suppliers can analyze a press and its applica-

tion requirements and build just the right hydraulic circuit for the job, at the right amount of performance and accuracy, and cost. "We have software tools that can analyze the dynamics of a press, and look at force-speed relationships, then match the valves, control cards and sensors to the dynamics of the machine," says Grube. "Using this software for the last four or five years, we've put presses into production more quickly, without having to reevaluate a press's performance and change out valves or other components."

The engineers at Greenerd couldn't agree more. "The best customer is one that knows exactly what it bought," says Lavoie. "If we know exactly what the press is required to do, then we can design the right press for the job and the customer will fully understand what the press can and can't do. For example, in deep-draw applications we can design the circuit to adjust ram speed and tonnage through the stroke, and make multiple hits during the draw. Using signature meters and profile systems, we can set a force-position window that the stamper uses to program acceptable limits, ensuring quality stampings. If part profiles are more complex, stampers can specify not just the force and position relationship but the actual shape of the force-distance profile and the percentage of variance allowed. This is critical, for example, in press-fit applications such as pressing a bushing onto a part."



Bosch Rexroth, with this NRB press-retrofit manifold, provides the redundancy required in the ANSI B11.2 hydraulic-press standard. The manifold, which installs inline between the lower rod end of the cylinder and the existing valving, contains two logic elements arranged in series hold the press ram up when the press is shut off.

Focusing on Press Safety

It's been seven years since ANSI issued standard B11.2, *Hydraulic Power Presses—Safety Requirements for Construction, Care, and Use*, and unfortunately many hydraulic presses in service still don't meet the requirements of the standard. Component suppliers such as Bosch Rexroth and Rockwell Automation have developed, within the last year or two, products aimed specifically at helping metalformers retrofit presses toward becoming compliant to B11.2.

A primary concern addressed by the standard is redundancy of critical components to eliminate any chance that a single point of failure causes a hazardous situation. In the world of PLCs, that means designing a "safe" control that, in effect, uses two brains that work together to control the system, rather than one brain controlling everything.

"When you have a single control, whether it be a PLC, relays or anything else," says Sullivan, "you have one brain controlling the entire hydraulic circuit. If you experience one single point of failure in that control then there's nothing to stop an accident from happening—power could be applied to the wrong place at the wrong time and cause a valve to shift or a cylinder to drop. It happens, and people can get hurt.

"With safe controls—either new PLCs or a retrofit redundancy kit," continues Sullivan, "the system takes direction from two controllers. Each controller independently analyzes all inputs and, before activating any output signals to the press, cross-checks the other. Only when the inputs look good to both controllers do they go ahead and apply power to something. This redundant cross-checking occurs every 5 milliseconds or so, scanning the control circuit hundreds of times per second. If something isn't where it's supposed to be, or the two controllers identify mismatched input data, they shut the system down."

Rockwell markets its press-control safety-retrofit kit, the 6556-MLHK, as a starting point to help metalformers meet the safety-control requirements of the ANSI standard. The kit allows stampers to wire up output actuators to the MLHK control unit, which then communicates to the main controller that signals are occurring at the right times. The main controller then activates the outputs safely. It's primarily concerned with the downstroking action of the hydraulic press.

Controlling the ram while it's up, with redundancy, also has been addressed by Bosch Rexroth, with its NRB press-retrofit manifolds. "To retrofit a typical down-acting stamping or draw press," says Grube, "you locate the NRB manifold inline between the lower rod end of the cylinder and the existing valving. Inside the manifold, two logic elements (high-flow pilot-operated check valves) arranged in series hold the press ram up when the press is shut off. This arrangement ensures that the rams stays in the up position even if one of the valves fails to close, providing the redundancy that the ANSI code requires."

Another way to add redundancy to the main cylinder is use of multiple jack cylinders to hold the platen in position, a solution Greenerd promotes when adding prefill circuits to new presses or as retrofits to existing presses. "Using jack cylinders to push the platen down, rather

than a gravity-style prefill design," says Greenerd's Lavoie, "not only allows us to generate greater stripping force on the platen, which helps in some forming applications, but it also provides redundancy where multiple cylinders hold the platen in position."

Further explaining the stripping-force advantage, Lavoie says that with an 800-ton press and a single prefill cylinder, stripping force might be only 50 to 200 tons. However, switching to a smaller main cylinder and applying four jack cylinders generate as much as 600 tons of stripping force.

Looking Toward the Future

While a retrofit manifold or control kit helps stampers address the most immediate safety concerns of an existing press, Rockwell's Sullivan urges metalformers to answer these questions: "What are you doing with your press today, and what do you see your needs being down the road? What performance limitations do you have today—do you want to go faster and smoother? And, do you envision bidding on more complex forming jobs? Will you have to generate more production reports? Do you need more flexibility because you expect to change dies frequently, maybe five or six times per day?"

Answering these questions helps a stamper decide whether to incrementally upgrade a press with retrofits, or perhaps purchase a completely new control system, one that integrates die monitoring, feeder control and other capabilities. "Today you might just have a press, but tomorrow you might want to have a progressive stamping press, or a transfer press," says Sullivan.

Greenerd's Lavoie sees the same evolution occurring in hydraulic-press applications. "We see increased use of progressive dies with hydraulic presses," Lavoie says. "As shops take their older mechanical presses out of production, we see them looking to use their existing progressive dies on hydraulic presses. The benefit here is that we can actually deliver a different forming speed for different points in the die. For example, we can set specific forces and speeds for the blank, punch, travel-through and stamp portions of the die."

The ability to run a variety of jobs in one hydraulic press, each with different tonnage and stroke requirements, has metalformers dreaming about the possibilities. As part designers learn more about the relatively boundless forming capabilities of hydraulic presses, and press builders develop ways in which to take advantage of cost-effective hydraulic components and controls, more and more of these smooth operators will be making their ways into press shops. **MF**