HYDRAULIC CUSHIONS

AND FLEXIBLE BINDERS CONTROL MATERIAL FLOW DURING DRAWING

Innovations such as intelligent hydraulic die cushions, that allow in-process control of draw cushion force, and flexible binder systems promise to revolutionize the effectiveness of existing mechanical presses.

BY BRAD F. KUVIN, EDITOR

Stamping automotive closure panels and other large drawn parts of challenging materials like aluminum alloys and high-strength steels pushes the envelope of what single-action mechanical presses can do, reliably and consistently. Other than invest in new hydraulic stamping presses, what's a stamper, faced with forming aluminum or thin-gauge HSS sheet, to do when he looks out at his still-capable lineup of mechanical presses? One answer lies in the use of intelligent hydraulic cushions, beginning to come of age as a way in which to make mechanical presses adjustable in-stroke.

When drawing sheetmetal panels, the primary objective of the die cushion is to set the bead. With the bead set, and without cushion control, eliminating problems such as orange peeling and fracturing by "working" the die becomes disruptive, time consuming and frustrating—welding, grinding, testing, welding, grinding, testing… The intelligent hydraulic drawing cushion changes all of that.

With hydraulic cushions, drawing-cushion force is freely programmable and allows the stamper to individually adjust drawing force at several locations of the draw die. This tonnage control can prevent the formation of wrinkles, and allow material to flow in precisely controlled amounts to prevent tearing.

Also, during the stroke, the cushion can be pre-accelerated, or set in motion before the slide impacts the blank. This pre-acceleration feature (see the diagram) dampens the impact shock by as much as 95 percent, improving die life and reducing noise levels by as much as 8 dB, according to literature from Schuler Inc. (Schuler and other press builders now offer hydraulic cushions for retrofit or installed on new mechanical presses.)

One more benefit comes in stamping of tailor-welded blanks, where cushion response can be customized to adapt for the varying material thickness of the blank.

Hydraulic Cushion in Action

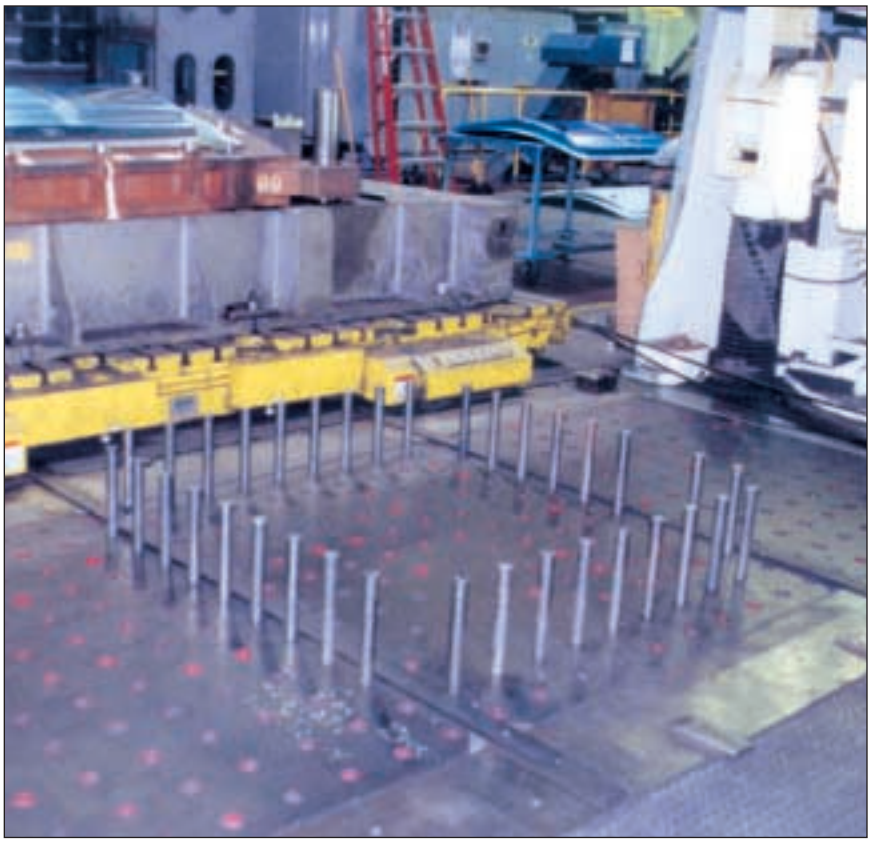
One firm believer in the bright future of intelligent hydraulic cushions

for mechanical-press upgrades is Chris Burbick, an engineer with die designer and builder Sekely Industries, Inc., Salem, OH. "We think it's only a matter of time before the automotive OEMs move toward hydraulic cushions in production stamping," Burbick says. "To stay ahead of the curve as a supplier of stamping dies, we felt that our only choice for cushion technology during a recent rebuild of a mechanical tryout press was a hydraulic cushion."

A turnkey provider of automotive line dies and progressive dies for 57 years, Sekely operates 17 tryout presses, ranging from 300 to 1800 tons. "I know that the press builders, such as Schuler and Muller Weingarten, are installing these systems at the OEMs," says Burbick. "So when we began our latest tryout-press rebuild, in 1999, we looked at our cushion options. We have several nitrogen press cushions here, but decided that we had to stay on the leading edge and go with the intelligent hydraulic cushions. In the scope of the overall rebuild, the price differential between nitrogen and hydraulic became relatively small."

Sekely installed a 450-ton hydraulic die cushion from Red Stag Automation Inc., Crivitz, WI, during rebuild of an 1800-ton single-action Hamilton mechanical press, with bed size of 180 by 100 in. Three 150-ton cushions with removable pins rest under the rolling bolster of the press. Four hydraulic cylinders per cushion allow Sekely to customize the force profile under the draw blank.

"We first viewed this technology at Autodie Intl., in Grand Rapids," recalls Burbick, "which has been using a single-cushion system from Red Stag since 1995. We approached Red Stag with our request for an added level of control. With our setup, we can program each of the 12 cylinders independently to customize the force profile during forming."



This hydraulic cushion, from Red Stag Automation, allows the pins to retract completely under the floor so that the bolster can roll out and enable quick die changes at Sekely Industries, Salem, OH.

Tears Disappear, Like Magic

Sekely has experimented with the cushion to eliminate wrinkles and tears without having to rework the die. However, since its customers for the most part have not begun to use the technology in production, Sekely must use traditional techniques for draw-die tryout.

Experimenting with the capabilities of the cushion, the most interesting success story to date occurred when it was working a die for forming a bedside panel for a pickup truck. One corner of the box side panel was splitting during forming.

"We decided, before reworking the die, to test the capabilities of the cushion," says Burbick. "We needed to decrease the tonnage in one corner of the die to induce sheetmetal flow and correct the split. In a matter of seconds, we reprogrammed two of the cushion cylinders, reducing their tonnage by 30 tons, made a hit, and the split disappeared. There were no negative effects from the changes—the rest of the part looked fine.

"To eliminate that tear using traditional tryout techniques," continues Burbick, "we might weld, grind and polish for two days. Carry that over into production—if they have splits and have to spend two days, maybe more, reworking a die, that's a big deal. Obviously, by quickly reprogramming cushion tonnage, downtime is dramatically reduced."

Pre-Acceleration Quiets the Process, Spares the Die

While cushion programming for production drawing has been used very little so far, according to Burbick, the pre-acceleration feature offered with hydraulic cushions is being used plenty.

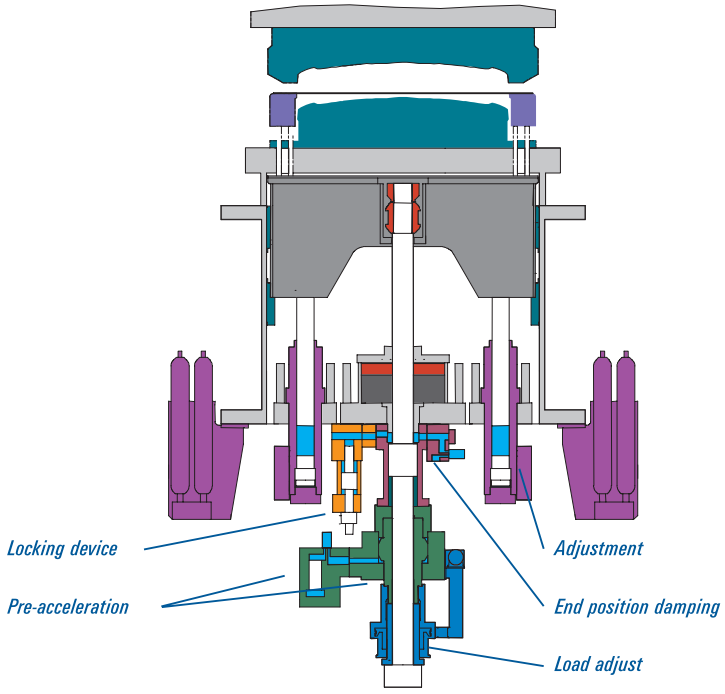
"We see some dies ordered with pre-acceleration built into their design," says Burbick, promising OEM stampers extended die life and helping to quiet their shops. "The hydraulic cushion allows us to properly try out these dies, to mimic production situations. If we tried to tune the dies using a nitrogen die cushion, for example, the customer would likely spend a lot more time doing tryout in their presses to fine-tune the pre-acceleration action, delaying production."

When we visited Sekely, the firm demonstrated use of the hydraulic cushion to form a truck rear-access door. The setup included a 164-by-94-in. die, with 4 in. of cushion travel. The 12 pressure settings for the cushion cylinders displayed on the control-station screen—force was set at 47 tons for the left-side cushion, 100 tons in the center and 33.5 tons to the right, to equalize force per pin.

One added benefit of the investment in the Red Stag cushion, not directly related to its technology, is the fact that this system is designed so that pins have enough travel to drop completely down into the floor, to allow the bolster to roll out of the press.

"Compared to our other cushion setups," says Burbick, "this significantly reduces the man-hours needed to change dies."

So sold is Burbick on hydraulic cushions, that he says on the firm's next tryout press, it would only consider hydraulic cushions.



Cross-section of a hydraulic drawing cushion, provided by Schuler Inc.

The Next Step: Flexible Binders

Current die designs practically limit the flexibility offered by varying cushion force—extremely rigid binders minimize the effect of varying cushion force. Rigid binders mean that cylinder force is spread over a fairly large area of the binder surface. On the other hand, an elastic binder would yield in a more limited area above the cushion pins, localizing deflection. The benefit: a change in tonnage would not affect areas of the die where it's not intended.

"The most difficult problem in drawing is when you have a wrinkle adjacent to a tear," shares Burbick. "A flexible binder would allow you to solve the wrinkle without the tonnage carrying down the die and worsening the tear, and vice versa. This will take a dramatic change in the way dies are designed, with a different approach to rib spacing, casting thickness and such," Burbick admits, "but industry researchers are getting closer and closer to standardizing some rules for flexible-binder design."

The research to which Burbick refers is proceeding under the umbrella of the United States Council for Automotive Research (USCAR), the United States Automotive Materials Partnership (USAMP) and the U.S. Department of Energy. Research into flexible-binder technology ramped up in 1996 when a four-year cooperative program between the automotive industry, academia, suppliers and the government began work to build a control unit for hy-

The Sekely press operator can view, on the cushion-control screen, the pressure settings for each of the 12 cushion cylinders and monitor their force during stamping. Should the part tear during forming, the operator can quickly edit the pressure profile at the control screen to allow more material flow in the area of the flaw.

draulic flexible binders to be installed on a mechanical press, and to demonstrate the technology on full-size automotive panels.

According to Dr. Mahmoud Demeri, project leader for the USAMP/DOE project titled Active Binder Control System for Robust Stamping (and a senior technical specialist with Ford Research Laboratory, Dearborn, MI): "Failure by wrinkling or tearing is highly dependent on the magnitude and trajectory of the binder force. Dynamic variation of the binder force during forming affects formability, strain distribution and springback."

Recent success in developing a binder-control unit has occurred at the Institute of Metal Forming Technology of the University of Stuttgart, in Germany, working in conjunction with Demeri's team. University researchers have successfully demonstrated how the use of cone-shaped segments located under the binder will localize applied pressure, from individually controlled hydraulic cylinders, in a specific area without affecting pressure in adjacent areas. The setup, with a 10-point cushion, has successfully demonstrated its capabilities on a full-size aluminum front fender to minimize wrinkling at the nose of the fender.

The program received a significant boost earlier this year when, according to Demeri, USAMP/DOE approved a new four-year $3.8 million commitment to further develop flexible-binder control technology and bring it to the production-readiness stage. Program objective: "To develop and demonstrate an optimized closed-loop control system for installation on mechanical presses, to produce quality stampings from aluminum alloys and high-strength steels."

Computer Modeling Key to Setups

Demeri's team recognizes the need for further development of computer-simulation techniques and process optimization in order to predict optimum binder-force trajectory at each pin of the hydraulic cushion, rather than controlling a smaller number of cylinders per cushion, as on the Red Stag setup. By simulating and predicting pin force, the team aims to minimize the trial-and-error procedure for setup and for adjusting force trajectories as process variables change during production.

Development of the software and hardware needed to simulate and optimize the forming process using flexible binders and to program multipoint hydraulic cushions is underway, under the guidance of Demeri's USAMP team, at the Engineering Research Center for Net Shape Manufacturing (ERC/NSM) in Columbus, OH. Under the direction of Ohio State University professor Taylan Altan, the ERC/NSM aims to develop software for use with any cushion system, including that from Red Stag, in conjunction with commercially available stamping-simulation software. **MF**