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# Servo-driven mechanical presses meet HSS head-on

*Control of slide motion, velocity puts stamper in the driver's seat*

By James Landowski

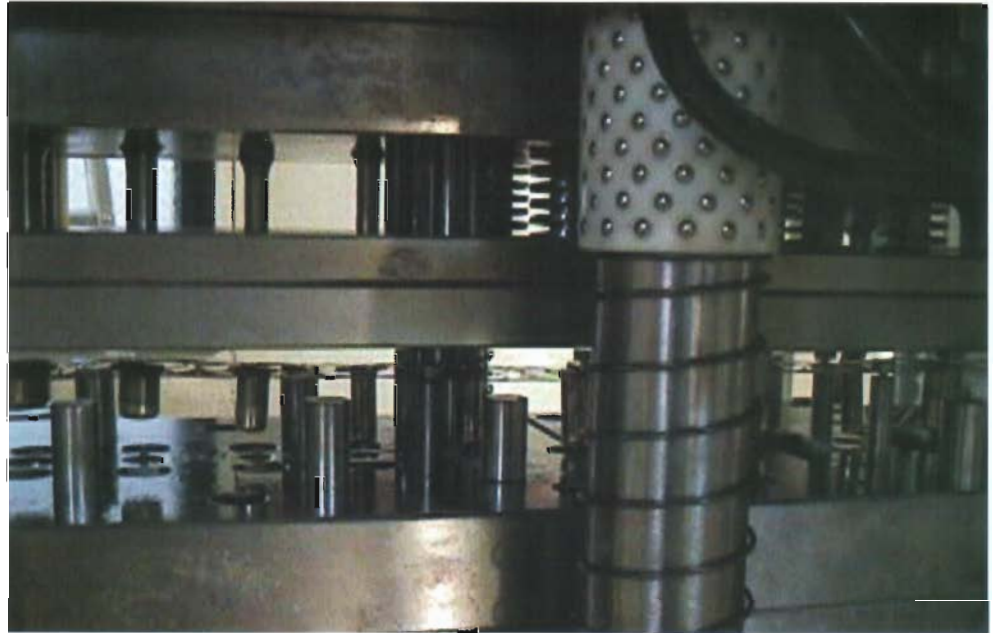
**T**he increased use of lightweight, high-strength materials—such as dual- and triple-phase steels that harden as they are formed and with tensile and yield strengths at or exceeding 100,000 pounds per square inch (PSI)—challenge traditional stamping. Blanking and forming high-strength steels (HSS) using standard mechanical presses usually require modifying traditional stamping processes.

For example, the stamper may need to preheat the material to form it; restrike it more frequently to set angles; add high-tech lubricants for drawing and tapping; and have more control of slide velocity to reduce reverse loads and prevent drawing fractures.

Blanking this material typically yields reverse loads, or snap-through loads, in excess of 40 percent or more, caused by sudden release of energy at material breakthrough.

As the material begins to resist the punch's penetration, the punch (and the corresponding press slide) is pushed upward, and all clearances in the drive train are taken up. When the breakthrough does occur, these clearances are instantly released and the slide propels forward, creating a shock wave that transmits through both the press and the tooling.

Reverse loads can be likened to a car driven forward at 50 MPH that is suddenly thrown in reverse for two seconds, then thrown back into drive with the pedal to the metal. The faster the slide motion and the stronger the material, the more energy is released at breakthrough and, therefore, the higher the reverse loads.



A recent mechanical stamping press innovation, the servo drive is designed to meet challenges related to stamping high-strength steels (HSS). Servo press technology allows extensive control of slide speed (velocity) and motion (dwell) in any direction and at any point in the stroke, and it delivers constant energy, regardless of the slide speed. Because slide speed is linked directly to the amount of the reverse load, being able to control the slide motion and velocity allows the stamper to reduce and nearly eliminate reverse, or snap-through, loads. Dwell allows the addition of secondary operations and permits the material to flow or set, which can eliminate the need for restriking.

Standard presses usually are designed to handle 20 percent maximum reverse loads. Reverse loads larger than this cause excessive wear on the tooling, excessive wear on the press itself, and inconsistent part quality. Forming angles and other part profiles within the designed part tolerance on HSS require more inspection and press and tooling adjustments throughout the shift.

Meeting these challenges requires not only getting a press with more tonnage, but also controlling the parameters of the stamping press. A recent innovation of the mechanical stamping press, the servo drive is designed to meet these challenges. Servo press technology allows extensive control

of slide speed (velocity) and motion (dwell) in any direction and at any point in the stroke, without loss of energy, at low slide velocity.

## How a Servo Mechanical Press Works

In a mechanical press, the spinning flywheel stores the energy for the press. Each stroke of the press causes the flywheel to slow down, depleting its stored energy. The motor must return the flywheel to its normal speed (replenishing the energy) before the next stroke.

In a servo-driven mechanical press, high-capacity servomotors replace the flywheel, motor, and clutch/brake. The

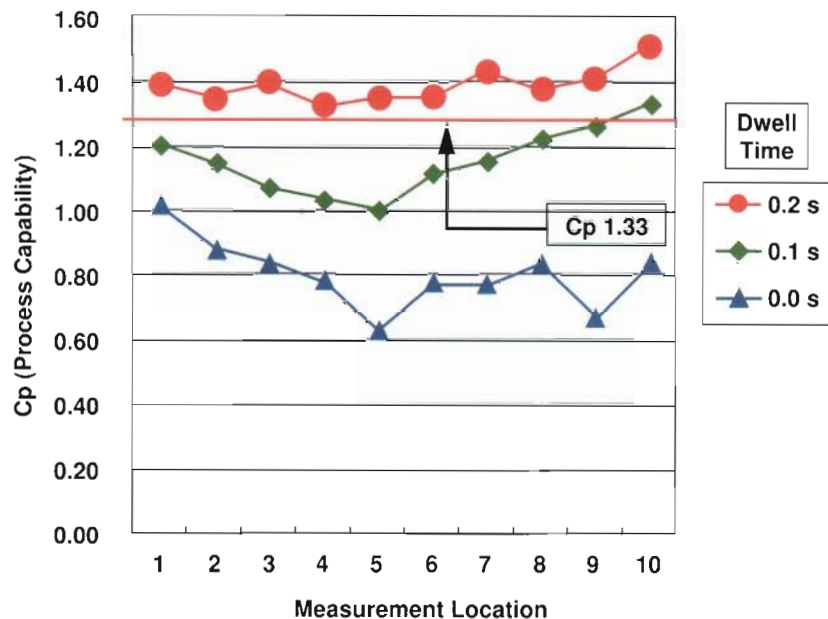
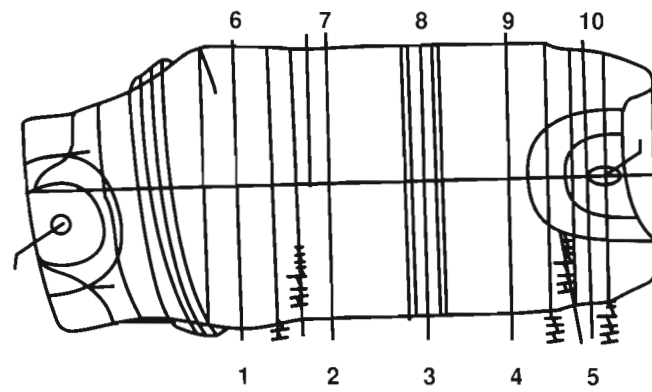
servomotor creates the energy and torque and is constant even when the speed is slowed.

**Tonnage and Energy.** In calculating the capacity needed in an application, both tonnage *and* energy are critical to the solution. The Society of Mechanical Engineers (SME) defines tonnage as the force (in tons) that can be exerted by the slide against the workpiece (defined as full tonnage rating at a distance above bottom dead center [BDC]). Energy is defined as the ability to deliver the tonnage through the distance required to make the part (commonly measured in inch-tons).

If a crankshaft or eccentric shaft with a connecting rod is used in the press drive train, the press has a unique tonnage curve with a rating point above BDC—regardless of whether the press uses a conventional flywheel and motor or servomotor to generate the energy. The difference is that in a conventional mechanical press, energy (which is created by the motor, stored in the flywheel) decreases when the flywheel slows down.

So how important is energy? Operators who have performed a simple 100-ton job that stalled after a few strokes in a 300-ton press could answer that question. When the flywheel has not had enough time to recover the consumed energy from the first stroke before engaging the tooling on subsequent strokes, the slide slows down on each stroke and eventually stalls; this is caused by a lack of energy, rather than tonnage. Often this is a critical and limiting factor in die design. Typically, a servo press has 30 to 80 percent more energy available than a comparable mechanical press.

**Control of Slide Motion and Velocity.** Servo technology allows slide motion to be controlled as simply as turning on and off a headlight. When the servo is on, it delivers constant energy, regardless of the slide speed. Because slide speed is linked directly to the amount of the reverse load, being able to control the slide motion and velocity allows the stamper to reduce and nearly eliminate reverse, or snap-through, loads. Controlling slide motion and velocity results in higher part accuracy in formed and drawn parts by allowing optimal material flow and reducing the shock



**Figure 1**

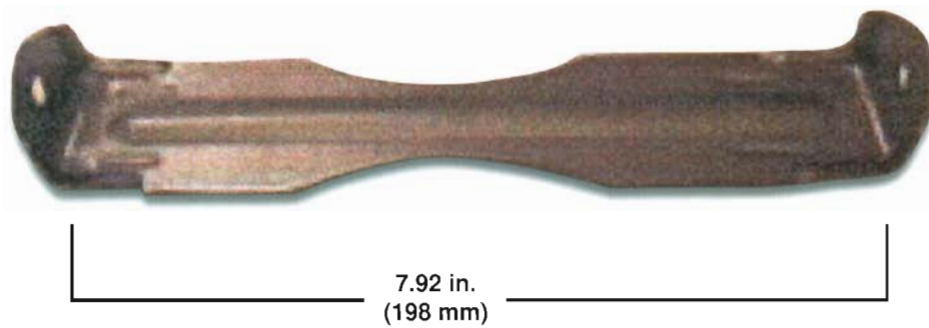
In a test conducted by a user of both mechanical and servo presses, productivity of a traditional flywheel-mechanical press and a servo-mechanical press was compared, using the same tooling and application. The test part was an insulator for a muffler made from HSS (75,000-PSI tensile strength). At 10 critical measuring points, the diameter tolerance had to be  $\pm 0.04$  in. The part was run in a 200-ton mechanical straight-side press with 7.8-in. stroke and link-motion drive with a fixed slide velocity of 0.40 m/s during the forming portion of the stroke and in a 200-ton mechanical straight-side servo press. The stroke and velocity were programmed to be the same as the mechanical link-motion press, but dwell time at BDC was added. The effect of the dwell at BDC had a great impact on the Cp value. The minimum acceptable Cp for this part—1.33—could not be attained consistently in a mechanical press, but was attained on the servo press. In addition, the Cp values were consistent throughout the shift, while die height adjustments needed to be made on the mechanical press during the shift.

in the tooling, thereby keeping the part stable in the die.

**Ability to Dwell in the Stroke.** Stopping the slide motion (dwell) at either side of BDC keeps the part captive in the die (like clamping the part in a vise) so adding secondary operations such as tapping, part insertion, and weld-

ing in the initial press operation becomes simple. This eliminates the need to send the part to another press for these additional processes.

In addition, adding dwell at BDC, in combination with controlling slide velocity, allows the material to flow or set, which can eliminate the need for restriking



**Figure 2**

In a second test, productivity of a servo-mechanical press was measured. The test part—a hinge for an automobile armrest—was run in a 200-ton gap-frame servo press, with the stroke at 9.8 in.. The speed ranged from 50 SPM (Cp 3.27) to 37 SPM (Cp 5.0) and the quality index was 3.27 Cp.

ing. It also simplifies the timing of automation, such as part transfer, indexing, and part insertion.

**Micron Accuracy.** New control advancements maintain slide repeatability, position accuracy, and die height deviation in microns stroke after stroke. A closed-loop control is a key component to this type of servo press. Servomotors provide the constant energy and torque, and the closed-loop control is key to monitoring and controlling the drive.

### **No Energy Loss With Less Power Cost**

A servo drive provides consistent energy regardless of slide velocity and consumes significantly less power than eddy cur-

rent drives and higher efficiency than inverter drives.

In a field test, electrical current consumption of both a 300-ton mechanical press with one 60-HP eddy-current motor and a 300-ton servo press with four 70-HP servomotors was measured. Both presses were run at 75 to 80 percent capacity. The servo press consumed 32 to 42 percent less electrical power than the mechanical press did.

### **Process Capability Index**

Today's competitive global manufacturing environment demands consistent part quality, which can be measured as an index (Cp or Cpk). A tooling and

press system that meets the part requirements, including critical tolerance, warrants a high process capability (Cp) rating. As once explained to the author, if arrows that are shot at a target land in nearly the same spot each time, that's a high Cp. Landing them all in a tight group in the bull's eye is a high Cpk. The higher the value, the better the quality.

Cp and Cpk are really about only one thing—quality. Cp is a simple indicator of process capability (the number of variations), and Cpk is an adjustment of Cp for the effect of noncentered distribution (variations from the target value). Servo press technology can greatly impact this measurement (see Figures 1 and 2).

### **When Is Fly-free for Me?**

Current servo press technology is not expected to replace all mechanical presses. Fly wheel-driven mechanical or hydraulic presses are still better-suited for stamping at speeds greater than 100 strokes per minute (SPM) and deep-drawing thick materials.

However, stamping applications that require forming, coining, and blanking of HSS and alloys; critical tolerances; and production speeds of 20 to 100 SPM benefit from servo technology.

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