

## More In Control Of Your Plant By Honing In On Hydraulic Systems

Hydraulic systems play a critical role in press operation, enabling the transfer and concentration of enormous force to press metal into desirable shapes in very hostile environments. However, conventional hydraulic systems can be highly inefficient, and lack the precise control necessary to achieve the highest levels of quality and productivity.

Press forming of metal is a predictable process, and many deformation simulation programs exist to assist in the pursuit of an optimal pressing cycle. The key to optimizing the cycle, both in terms of productivity and part quality, is the control of press velocity to achieve intended material flow characteristics during deformation.

Traditional hydraulic systems control press ram velocity in one of two ways—multiple discreet fluid flow transitions by adding or subtracting flow provided by multiple pumps, or by using combinations of servo valves and proportional throttling valves with associated control cards and feedback sensors.

A third alternative, offering the highest level of ram velocity control and precision, is now available using the UNiGY system's pump-modeling hydraulic-drive™ technology (PhD). The advantages of this technology for energy savings and elimination of oil cooling have been well documented for this technology, but a recently filed U.S. patent application cites two additional benefits of applying this technology to press applications: Precise control of press velocity, and sensorless diagnostic datalogging of both press and hydraulic power supply performance.

### A Smart Pump Control System

Used in the forging and metalworking industries, among others, the UNiGY® system is a positive displacement pump-modeling solution that uses the PhD, motor, and pump as instruments to precisely control fluid pressure and flow, while providing sensorless data for process control and diagnostics. The UNiGY system accepts incoming control signals, sent from either a computer or traditional PLC controls, and accurately matches pressure and flow curves deduced from material deformation predicted by finite element model (FEM) programs, such as DEFORM.

The press ram velocity profiles can be controlled based on real-time hydraulic control of the UNiGY system. The digital nature of the UNiGY system enables press cycles to be highly consistent and offers high resolution, even over long periods of use and for the duration of press life.

The system achieves high efficiency by applying on-demand hydraulic power for the press process, and does not require the complicated valve and cooling systems used on traditional hydraulic-drive systems. You can use a variety of pumps and

motors with the UNiGY controller, and many have performed successful retrofits on hydraulic presses.

Recently, Kadant AES, inventor and manufacturer of the UNiGY system and a division of Kadant Inc., filed a patent for the third generation UNiGY system, which includes DiaLog™ software, which allows for advanced system diagnostics. DiaLog software maintains an electronic log of the pressures, flow, timing, events and more than 60 other variables during each cycle of a hydraulic press.

This data provides valuable insight into the deformation physics of the workpiece as it is formed to the die. The patent also covers the system's pump-modeling hydraulic-drive technology that provides reliable force control, velocity control and position control with use of the prime mover as an instrument.

### **Achieving Precise Process Control**

Velocity of the ram correlates directly with the flow rate of the fluid delivered to the ram cylinder, and can be varied by accelerating or decelerating the rotational speed of the pump. Certain press cycles require very specific velocities at different positions during the cycle, and the UNiGY system's precise control of flow volumes and velocities gives faster, smoother transitions—without the excessive sensors and external controls required for traditional presses. This eliminates the feedback lag common to downstream-mounted control device.

The UNiGY system also monitors the torque of the motor, factors in the self-learned mathematical pump model, and directly controls the pressure and flow of the hydraulic fluid. The fluid pressure, combined with the diameter of the ram piston, provide instantaneous knowledge of the forces experienced during a cycle without extraneous feedback instrumentation. DiaLog software not only displays the process in real time, but also records the information for later review and optimization.

The UNiGY system calculates the exact speed of the ram based on its mathematical model of the pump, automatically compensating for predictable variations in pump slip that occur at various combinations of pressure, fluid viscosity and pump speed. Figure 1 illustrates the slip characteristics of a commercially available pump analyzed by the UNiGY system's PhD. The system's smart pump control capabilities mean that any complex velocity profile can be easily duplicated in the press cycle without the time-consuming analytical and iterative processes.

While conventional hydraulic systems using proportional control valves, control cards, PID loops and sensory feedback for system tuning enable a certain level of press control, the results can be imprecise, slow and inconsistent over time. By employing real-time automated hydraulic control that compensates for mechanical system and process variations, and making decisions based on algorithms, the UNiGY PhD technology eliminates the need for additional feedback devices and provides consistent press cycles with minimal instrumentation.

The UNiGY system's pump control technology for hydraulics allows seamless integration with any logic center for process-specific hydraulic control. It interfaces

and relays information in engineering units understood by the operator specific to the process. As shown in Figure 2, the DiaLog software records all hydraulic information for a press-fit part deformation for real-time process control and optimization, or subsequent quality control.

The UNiGY PhD, furthermore, has a volumetric observer to provide positioning information for a particular ram. It combines the volumetric pulse value with ram diameter to determine coarse ram position—typical  $\pm 0.060$ —without the use of a linear transducer.

### Diagnosing Pump Health & System Anomalies

The UNiGY system's pump-modeling functionality provides hydraulic compensation of pump output resulting from variations caused by wear and tear on the pump and system. Bounded by parameters set by the system designer, the UNiGY system accounts for hydraulic losses such that the end application does not see a difference in performance.

Rather than employing multiple discrete devices and operator supervision to ensure the health of the hydraulic system, DiaLog software's data-mining capabilities, and the PhD's real-time monitoring and control capabilities, work together to achieve this result. While the software maintains a consistent log of operations, the PhD microcomputer's algorithms and observers continuously monitor the health of the hydraulic system—including the pump to help ensure the pressure characteristics of the first press cycle and the 10,000th cycle are identical.

Figure 3 shows a comparison of a healthy four-piston pump compared to a problematic pump. As long as the pump anomaly does not create a hydraulic loss beyond the tolerance set by the system designer or user, the UNiGY system manages the pump for consistent press performance with respect to velocity and pressure control. Any deviation from the set boundaries can be reacted to in various ways, including warnings, faults or system shutdown. This has a direct influence on end-part quality as the press can produce consistent parts, even with partially problematic pumps.

When anomalies occur, such as a clogged filter or a leaking check valve in a piston pump, UNiGY PhD immediately identifies the problem and executes procedures to protect the system, then alerts the operator, and adjusts applied pump torques and speeds to maintain commanded pressures and flows when possible.

UNiGY PhD samples 8,000 data points per pump revolution to allow for immediate and high-resolution control of pump behavior. Additionally, you can customize these responses to reflect the severity of the problem. A burst pipe, for instance, can result in an alarm and the instantaneous shutdown of the system. A partially clogged filter, on the other hand, can result in a log entry while the system makes up for the change in flow or pressure levels.

Due to extensive pump modeling, DiaLog software can identify which piston is failing in the case of a pump failure long before it becomes catastrophic. Simple periodic pump snapshots as seen in Figure 3 can reveal minor issues before they

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become major. Traditional hydraulic systems provide little or no definitive error feedback. As a result, trained technicians must spend vast amounts of time to troubleshoot the machine to identify and repair the problem.

With the UNiGY's simple system integration, datalogging and diagnostic capabilities, press applications can now experience precise press control and intelligent system diagnostics in addition to energy savings.

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