By RICHARD T. SCHNEIDER

Genesis of a hydraulic shock absorber

Hydraulic shock absorbers decelerate loads by converting their kinetic energy into heat, then dissipating that heat to the atmosphere. Typically, a load contacts and strokes a piston to displace oil inside the shock absorber and force it through engineered orifices. After the load is removed, a mechanical device, usually a spring, returns the piston to its rest position.

When the design team at ACE Controls Inc. set out to develop the Magnum Group of shock absorbers — using our established Primary Series as a model — we had five major goals:

- increase the energy capacity by 50% without increasing package size
- provide a fully threaded body
- maintain all current mounting options for direct interchange with existing installations
- include an integral stop collar, and
- arrange for adjustment from both front and rear of the shock absorber.

To accomplish these goals would expand the application possibilities of the new product, but to the design team, they simply demanded, "Get 50% more capacity out of a smaller package," a set of seemingly incompatible conditions.

For example, the only way to raise the energy rating without lengthening the body was to increase the piston diameter. But a larger piston would create an accumulator problem. Here's why: in the Primary Series, the middle of the body is enlarged to house an accumulator which consists of closed-cell foam. When the piston rod enters the oil chamber, it displaces some oil, forcing it through the orifices. Resulting high oil pressure collapses the air pockets in the foam. The foam acts as an accumulator for oil displaced by the piston rod.

However, our new profile eliminated the enlargement and the full threading thinned the walls. This squeezed the design in two directions — the effective body OD was getting smaller, while the major internal component was getting bigger. We had to search for a way to regain the accumulator volume.

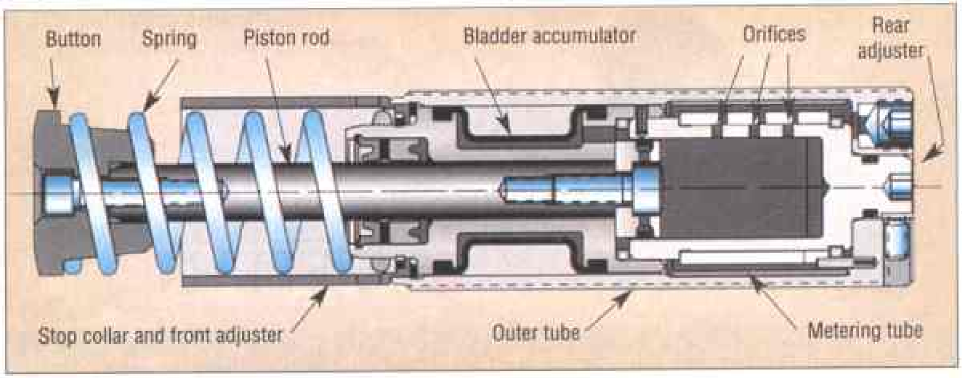
The team tackled these situations first by optimizing the piston diameter, then calculating what wall strength was needed by each of the components under load. We then experimented with hollowing out other internal parts, such as the bearings, and filling the space with foam. However, subsequent cycle testing showed that the volume we gained was insufficient. Higher compression fatigued the cell walls and deteriorated the foam. We had to rethink our accumulator methodology.

Our conclusion: the closed-cell foam (which performed very well in many other products) contained too much solid material for the new tighter configuration. The foam in the Primary Series averaged 46% solid material by volume. We needed an accumulator that was mostly air; our solution was to substitute a bladder. With a bladder, a much higher percentage of the volume was available for compression.

We then turned to the adjustment issue. Existing designs (both ours and our competitors) provide adjustment via pins or cams mounted radially to the shock absorber axis. These devices move some individual part inside the shock absorber relative to the rest of the mechanism. In our Primary Series, a knurled adjuster ring on the OD of the shock incorporates a pin that passes through a slot in the outer tube. This pin engages the bearing, which in turn engages the metering tube. As the adjustment ring is turned, the metering tube also turns around the stationary inner tube. This causes tapered slots in the metering tube to partially cover the orifices drilled in the inner tube.

Rugged Magnum Series shock absorbers have fully threaded bodies, in either self-compensating or adjustable designs. Energy ratings extend from 1350 to 54,000 in.-lb/cycle

To provide adjustments at both the front and the rear of the shock, we had to consider not only the path needed to link the front and the rear, but also which internal components should be fixed and which should move. The stop-collar requirement dictated that the front adjuster also had to serve as either the positive stop or as the mounting point for the positive stop. Another consideration: the Primary Series had threads on the front and rear that allowed a variety of flanges to be added to accommodate different mounting configurations. But in the redesigned shock absorber, all items in the front — button, spring, rod, and positive stop — must pass through the minor diameter of all current mounting hardware.



Cross-sectional view of MA Series adjustable shock absorber in Magnum Group.

Acknowledging that the internal components of the shock had to be linked together to provide a continuous path through the shock, our design engineers first analyzed how to provide the rear adjustment. In the Primary Series the metering tube turns, but because the inner tube covers the center of the rear of the shock, they determined that it would be easier to allow the inner tube to extend through the rear of the shock. Adjustment would be direct, without adding another mechanism to the metering tube. In effect, they reversed past practice. To minimize the size of the extension, they chose a standard Allen-key hex hole as the adjuster driving mechanism. After this decision was made, they were able to link the inner tube to the front bearing assembly. Because we wanted to add an integral stop collar, it was logical to make the stop collar also serve as the front adjuster.

Wall thickness had a couple of additional size constraints. The outer diameter of the stop/adjuster could be no larger than the minor diameter of the externally threaded body, and the stop had to allow the return spring and the button to completely fit inside its walls when the shock was fully compressed. Providing this room without compromising the strength of the stop required a careful design-balancing act involving material selection, heat treatments, and dimensioning of components.

When the Magnum Group design was finished, the new shock absorbers had the required high energy ratings per package size. The group covers a range from 1350 to 54,000 in.-lb per cycle — comparable to most mid-range indoor shock absorber applications. The line includes adjustable and self-compensating models. As in all ACE products, precision-machined sharp-edged orifices are the key to consistent performance. Longer bearings handle higher side loads. High-strength material extends service life. And the designed-in mounting flexibility saves cost and installation time for our customers.

Michael A. Ferkany
Engineering manager
ACE Controls, Inc.
Farmington, Mich.
Telephone: 248 / 476-0213
Fax: 248 / 476-2470

Hydraulic analyzer works with notebook PC

SIM-Check portable analyzer passes real-time information from sensor arrays on hydraulic system to notebook PC for display and analysis.

The SIM-Check portable analyzer is designed to help maintenance personnel diagnose and monitor the operating efficiency of multi-functional hydraulic systems in one step. Developed by Flo-tech, Racine, Wis., SIM-Check gives users real-time information in an easy-to-understand format. The analyzer will pinpoint trouble areas in the hydraulic system, allow monitoring of flow priorities, and let the user make well-educated inferences about the performance of specific components.

A single SIM-Check analyzer can simultaneously measure as many as eight operating parameters from up to four sensor locations; then process the information and report on characteristics such as volumetric and overall efficiencies, and power loss. Typical hydraulic operating parameters that can be measured include flow, pressure, temperature, and speed. The SIM-Check analyzer can report on combinations of parameters and/or show differentials between them.

The SIM-Check analyzer works in conjunction with a standard user-provided notebook PC, using proprietary Flo-tech interactive software that runs under a Windows platform. The user selects from a series of menus and buttons to configure the software to the system, to move within the program, to select features, and to view data. The mouse and keypad are the only tools the user needs to input and receive real-time or archived data.

Sensor arrays, furnished by Flo-tech, are mounted in hydraulic lines or other convenient places in the circuit. Each sensor array combines pressure, flow rate, and temperature sensing in a single unit, thus simplifying installation. The sensor arrays transmit real-time data via conventional 4- to 20-mA signals to the Sensor Interface Module (SIM). The SIM has four input connections for two sensor arrays and two auxiliary sensors, one output connection for a PCMCIA card, and an input connection for recharging its internal battery. The SIM converts the sensors' signals into 5-V DC signals, then transmits the converted information to a PCMCIA Type H card (also furnished by Flo-tech) installed in the PCMCIA slot on the notebook PC.

The SIM-Check software runs under Windows 95 or 98 platforms. When running, the software allows the operator to move easily from one menu-driven screen to an another, observe data from a single sensor array, compare data from two sensor arrays, or monitor changes in system parameters over time. Users can elect to see real-time, comparative, or derived information, as either specific data points or visually as a variety of time-based graphs.

Point-and-click hot buttons on the screen allow the user to customize the software to specific measurement needs — whether U.S., SI, or other traditional measurement systems. SIM-Check software also lets the user point and click to set flow ranges, nominal pressures, temperature limits, and alarms.

Contact Robert Bartling, Flo-tech sales manager, by phone at 262 / 639-6770, by fax at 262 / 639-2267, or by e-mail at robbartling@racine fed.com.