Sensing a change

Hydraulic engineers are being pressured to design systems that perform more tasks while taking less space.

by **Terry Costlow**

Parker's multiplexing module serves as both a network node and an operator interface.

Sensors from MTS come in a number of different configurations.

The increased use of sensors in hydraulic systems provides engineers the insight needed to improve safety and reliability without driving up costs or fuel consumption.

Sensors provide an array of data that makes it possible to automate tasks such as digging or positioning arms and booms. This information, along with data from other sensors, can also be used to make sure loads and vehicles are stable. That focus on safety is becoming more important as regulators examine more facets of society.

As solid-state sensors are added to equipment large and small, system engineers and programmers are enhancing the capabilities of electrohydraulic systems. Suppliers note that the availability of valid data is critical for these advances.

"Software engineers usually love sensors," said Brian Cox, Technical Marketing Manager, **MTS Systems**' Sensors Division. "Often, they've been dealing with systems that weren't optimal and supplied data they couldn't really trust."

Sensors also make it easier to move to higher pressure levels without worrying about safety, helping designers shrink the size of pumps.

"There's not a lot of real estate on off-highway equipment, so people want smaller packages. That requires working at higher pressure levels," said Steven Zumbusch, Senior Manager for Application & Commercial Engineering, **Eaton**'s Hydraulics Business.

The big picture

Sensors alone are worth no more than controllers without input. The electronic components in hydraulic systems must work together with engine controllers to gain maximum efficiency. These distributed systems are linked by networks.

"For machines to become more productive, more reliable, and operate at lower cost, sensors will be needed to measure more aspects of the machine. Sensors will become smarter as systems become more distributed," said Kirk Lola, North American Marketing Manager for Mobile Electronics, **Parker Hannifin**.

That trend toward distributed systems makes it more critical for various design teams to work together. As electronic controls handle more tasks and free operators from handling even the most minute detail, there must be closer cooperation between the teams that design each aspect of the overall machine.

"Companies are saying they need to take more of a system view," said Cox. "When we work with customers, now we're talking with hydraulic, mechanical, and electronic guys. For a lot of advances to take place, you need diverse input."

When sensors were embedded into a hydraulic cylinder, sensor suppliers spoke only with the cylinder designers. Now, cylinder engineers are part of the system approach; they do not do the design alone, he explained.

Those cylinders are typically linked to an ECU that controls a number of elements throughout the hydraulic system. Feeding all this data to a central controller helps ensure that all the cylinders and other equipment are working together at maximum efficiency while eliminating some control modules.

"Engineers can eliminate the master-slave approach by going to

systems where each cylinder is controlled individually," said Cox. "You can synchronize hydraulic elements with electronic controls by reading the sensors on each hydraulic element."

Adding some processing power to the sensors helps address this system-wide approach. Distributing intelligence provides a number of pricing benefits.

"Placing more computation power in the sensor not only reduces installation wiring costs, but also decreases overall machine service costs by allowing faster and more accurate diagnostics," said Lola.

Those improved diagnostics are expanding as product developers get more data. Gathering this input is a bit like eating Cracker Jack: The more data engineers get, the more they want.

"As machines become more sophisticated, the control systems will require more information. Sophisticated sensors will measure things like hydraulic-oil quality, engine emissions levels, component vibration, and component loading," said Lola.

Making the most of all this information requires a concerted effort by developers from all disciplines. By working together, they can gain benefits without pricing themselves out of the market.

"It's really important to have all parties working together to effect change," said Cox. "You need a system-level knowledge of the machine to understand what changes can be provided without driving the costs too high."

Safe and sane

Among the many reasons engineers are using more sensors, safety and reliability stand out. Safety is particularly important in today's litigious environment, where government regulations often ask equipment designers to help protect the public as well as operators.

"More and more, sensors are integrated in for closed-loop feedback," said Cox. "Some of that is due to regulations. In something like a crane, you need a higher level of safety."

That focus on safety comes in many forms. Sensors can prevent operators from moving arms or booms beyond safe points that are reset as conditions change. Sensors can also make sure that payloads are not lost when they are being moved.

"Sensors are being added that measure hydraulic pressure for stability and load sensing," said Karmjit Sidhu, Business Development Vice President, **American Sensor Technologies**. Sensors can protect equipment as well as operators and payloads.

When safety is involved, designers need to ensure that controllers are making their decisions based on valid input. When sensors fail, they must report their problems so that the system can be shut down or put into a limp-home mode. The host can not be stuck in a dangerous state waiting for input.

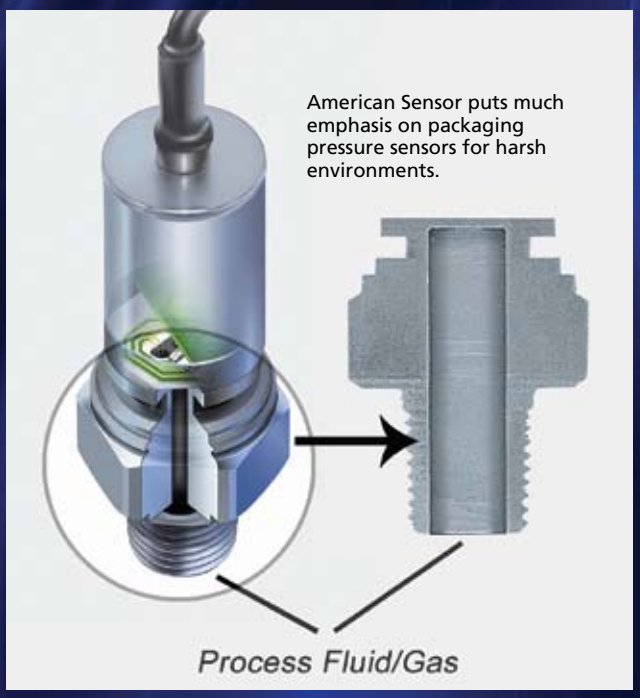
"In the past, we focused on reliability. Now, we also have to make sure sensors don't get into an unknown state. System designers need to ensure that the electronic controls can trust sensor inputs," said Cox.

The increased focus on safety does not make reliability any less important. When sensors are embedded into valves and pumps, they must work over longer periods so an expensive valve does not fail because of a comparatively inexpensive sensor.

In applications such as position sensing for booms, safety and reliability are closely intertwined. Most off-highway environments are extremely harsh. Components must live in these environments over the long lifetime of industrial equipment.

"Sensors have to work in extreme temperatures and with nasty vibration. They could be on the end of an arm that's vibrating like crazy," said Sidhu.

Processors and sensors are embedded in Eaton's Ultronics valve.



American Sensor puts much emphasis on packaging pressure sensors for harsh environments.

Reliable network connections are critical for MTS sensors that are embedded inside pumps and valves.

CAN links hydraulics to other systems on all types of vehicles.

Sauer-Danfoss

Making a connection

As more sensors are scattered around the vehicle, the amount of intelligence at these remote sites is also growing. Distributing intelligence changes the architecture and puts much more emphasis on communications between the nodes.

Another approach to distributed intelligence is to dedicate controllers to subsystems such as booms or lifts. Regardless of how microcontrollers are configured, communication will become a critical part of the design.

"Several small to mid-sized ECUs will be positioned close to the implements they control, performing specific tasks. Networks such as CAN will become more and more important," said Christiana Seethaler, Off-Highway Electronics Teamlead, **TTTech Computertechnik**.

These networks will make it much simpler for controllers and operators to know exactly what is going on with system components. They also help product designers cut costs because data is readily available throughout the network, making it possible to share data.

"Information from sensors is put on the CAN bus for any system," said Dan Ricklefs, Product Portfolio Manager, **Sauer-Danfoss**. "It's not tied to any specific controller. If the hydraulic controller wants to monitor engine speed, it can get it from the CAN bus instead of adding another controller."

That's not the only way that networking helps reduce costs. It also makes it easier for manufacturers and dealers to add or remove some functions.

"Distributed solutions include less cabling costs and support of modular architectures," said Seethaler. "For vehicles on which special implements are not mounted, there is also no need for the dedicated electronics to be on board."

On larger equipment, subsystems may have their own network. As in passenger cars, engineers find it simpler to put a few different networks on a vehicle instead of designing one large net.

"There's no overriding approach to networking; it's common to break up CAN buses and put three or four on a vehicle," said Ricklefs. "You might have a critical piece of hydraulic system that has its own CAN bus, for example."

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Having reliable sensors that monitor high-pressure systems can also help prevent errors. Increasingly, engineers use data to predict failures by alerting operators that parameters are exceeding normal ranges.

"Sensors can help you predict failure," said Zumbusch. "A failure at high pressure has the possibility of being much more catastrophic."

Sensor elements

When engineers pick sensors, price and quality are at least as important as specifications. One bright spot is that there are only three main parameters for pricing and product reliability.

"In many sensors, you've got three parts to costs and reliability. One is the sensor, second is packaging, and third is test and calibration," said Sidhu.

Sensor costs continue to decline as higher volumes of these solid-state devices are produced. Volumes are also helping to drive down packaging costs. The trend to embed some processing capability into sensor packages is helping reduce the cost of calibration.

"Smart sensors reduce system development time by allowing predefined and tested components to be used," said Lola. The processors can make many of the adjustments needed to compensate for the variations of sensor outputs.

On the reliability side, engineers are relying on improvements in manufacturing capabilities and higher quality levels. Sensor packages often require extremely high-quality seals that work in extremely harsh environments.

"If the sensor's packaged in a valve and is sensing hydraulic oil, it can't leak," said Sidhu. "That's also true if you're protecting the sensor from outside contaminants, like water." ***sohe***