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# FEA Peels Away Mysteries of Hydraulic Valves

*Combined methodologies yield new insight*

By marrying the mathematical precision of finite element analysis (FEA) with an in-depth knowledge of hydraulics, engineers at Moog GmbH (Böblingen, Germany; http://www.moog.com/Industrial/) are shedding new light on hydraulic valve design by "peering inside" operating valves.

A paper written by two Moog engineers (http://rbi.ims.ca/3850-551) brings new insight into the operational problems of valves by showing how engineers can use simulation to deal with such issues as pressure-related deformations and flow-related forces within a valve.

The ability to do that could represent a major advantage for valve designers and users because it enables engineers to resolve sticky field problems for customers and predict the effects of hydraulic conditions before prototypes are built.

"There are some things we cannot measure and can only understand through simulation," notes Christoph Boes, engineering manager for electronic feedback valves at Moog GmbH. "On the mechanical side, there are deformations we cannot [ordinarily] see. On the flow side, there are effects we can't measure because we can't install transducers or sensors inside the valve while it operates."

Moog co-authors Matthias Finke and Dirk Becher apply structural FEA, computational fluid dynamics, magnetic modeling, and dynamic simulation to salve such problems. They use structural FEA, for example, to examine the deformations inside a valve body subjected to hydraulic pressures of approximately 5,000 psi. Although such pressures can sometimes cause sensitivity issues (known as "sticking spools") in servo valves, the authors show how the valves can be redesigned to prevent such problems.

Sometimes, they say, the internal geometry of a ductile iron valve body can be deformed under such pressures, causing the spool-related sensitivity problems. By switching from ductile iron to machined steel, however, such deformations can be eliminated, they add. "We can do an estimate of the deformation before manufacturing the parts, and then create a good fit so that you don't have the sensitivity issues anymore," Boes says.

Similarly, the authors use computational fluid dynamics to calculate flow forces on a valve spool. Empirically determining such forces is nearly impossible, they note, because the addition of sensors to the valve body changes the flow dynamics of hydraulic fluid moving through the valve. By employing simulation, however, engineers can simulate flow forces and determine if compensation is needed to help actuate the valve's spool.

"If you modify the geometry of the spool or body, then you can compensate for the flow forces," Boes adds. "And if you do it in a perfect way, you can compensate the flow forces down to zero." As a result, Boes says, engineers can design a valve that performs optimally, even in the face of high flow forces.

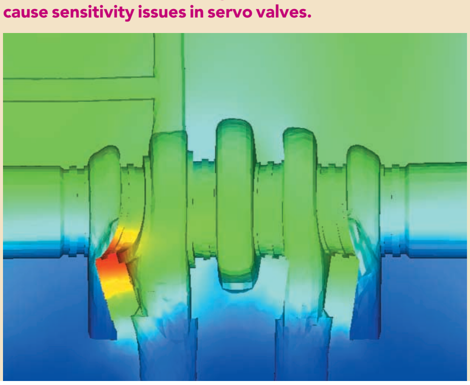
Moog engineers mention that hydraulics manufacturers have made limited use of FEA for such applications in the past because the calculations can be extremely intensive. Hydraulic problems tend not to be axisymmetric, they note, and therefore require high numbers of computing nodes and dozens of hours of computing time. A typical hydraulic valve problem, they claim, often takes 40 hours. The availability of high-powered desktop computers, however, has made such efforts possible. For the problems mentioned in the technical paper, the company's engineers ran NASTRAN 4W and ANSYS software on a Pentium 4-based PC.

The company claims the results are worth the effort. Benefits include reduction of development time and cost, improved sensitivity of servo valves, and ability to solve field problems for customers.

In one instance they cite, Moog engineers solved a problem for a customer that wanted to run a valve at pressures more than 50 percent above the valve's rated maximum.

"The customer might just need a change of material or a change of geometry or both," says Finke, a Moog development engineer. "By doing a simulation, we can understand better what needs to be changed."

**BEFORE:** **FEA models reveal pressure-related deformations in a ductile iron casting. Such deformations can cause sensitivity issues in servo valves.**



**AFTER:** **By switching from ductile iron to machined steel, deformations can be reduced or eliminated.**