LOOKING INSIDE THE VALVE

Modern control valves can monitor pressure and flow control in a full range of specialist process industries. Now, better prediction of a valve's performance can be calculated and it is possible to find out what is really going on inside a valve.

Asher Glaun
Masoneilan, Dresser, Inc

Many process industries as well as specialty industries such as aerospace, military and nuclear can all benefit from modern control valves. Most control valve manufacturers produce valves that conform to International Electrotechnical Commission (IEC) standards. These provide methods for the testing, sizing and acoustic performance of control valves. They typically apply a physics-based approach, coupled with manufacturer-supplied valve factors, to calculate a valve's performance, allowing consumers to rate the valves of one manufacturer against another.

The IEC methods work well on many traditional valve styles, but they do not give a full picture of what is actually going on inside the valve. By definition, they do not predict performance for newer, innovative designs. However, computational fluid dynamics (CFD) is an ideal tool for this task. CFD allows the modelling of incompressible fluids, such as liquids, and compressible fluids, such as gases. Modern CFD programmes can comfortably handle compressibility effects such as ideal gas behaviour and subsonic/sonic transitions.

In-depth analysis

A Masoneilan 21000 globe valve with a contoured plug was modelled to verify CFD prediction. Many years of Masoneilan laboratory test data were available with which to compare the CFD results and a maximum difference of 2.9 per cent in mass flow was calculated for several applications. These results provide proof that CFD software is correctly calculating the flow field and that it can also provide a deeper analysis of the results. Particle-laden flows produce unique problems in control valves, namely abrasion and erosion. Abrasion due to entrained particles is highly dependent on the velocity and the angle that the velocity vector makes with the surface. CFD predicts the velocity field in the valve, which aids in the accurate placement of abrasion-resistant materials.

The Masoneilan V-Log valve trim provides numerous tortuous paths through which vapour or gas is driven, producing a large pressure drop and significant noise reduction. In many applications, such as in this one, aerodynamic noise is a major design consideration with some applications generating levels in excess of 100dBA. Freely expanding jets of gas generate most of this noise as they exit the valve trim. Consequently, the accurate prediction of exit velocity is important in designing a quieter valve trim. Additionally, jet interaction will attenuate jet noise, which can be predicted by the CFD model. CFD pressure profiles alert the valve designer to areas of the channel where extremes of pressure, velocity and temperature occur. The V-Log channels may be redesigned, based on this information, in order to prevent fluid phase change and phenomena such as hydrate formation in natural gas pipelines.

An informed decision

Textbook thermodynamics is often used to estimate velocity, pressure and temperature inside the valve trim. These analyses, however, assume average properties based on the fluid uniformly filling the flow channels. CFD results show a different reality, where the flow field has local areas in which fluid properties may differ substantially from average values, allowing the designers to make better informed engineering decisions.

Laboratory testing is still the final arbiter of the performance of a new valve design. CFD, however, has successfully been used to greatly reduce the time taken to reach a final design by eliminating non-performing prototypes and showing the way to a high-performance final design.

A range of benefits

CFD provides a completely new view of the fluid dynamics inside a control valve. This view gives designers a chance to better understand how changes might impact valve performance and a chance to innovate based on these insights. Critical applications can benefit from the accurate calculation of extreme values of temperature, pressure and velocity to control condensation, cavitation, erosion and noise. *

Author

Asher Glaun is the senior development engineer for Masoneilan based in Avon, Massachusetts, USA. Masoneilan is a leading manufacturer of control valves and instrumentation with a history of experience, knowledge and technology in flow control for the process industry. Masoneilan is a part of the flow control division of Dresser, Inc.