Focus on Nuclear Power Generation

Kalsi Engineering:
leaders in innovative valve design, analysis and testing services

Design and manufacturing controls applied to nuclear valves

Welding in the nuclear power industry

Improving nuclear plant safety through solenoid valve technology

Selecting code-certified fluid system component suppliers

Nuclear news, products, projects and symposia

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Kalsi Engineering, Inc., (KEI), founded in 1978 is a high technology firm providing consulting engineering services in the areas of research and development, design, analysis, and testing of mechanical equipment and structures. Kalsi Engineering enjoys world-wide acclaim for its consulting expertise and products in valve and sealing technology, especially wherever the demand for safety and reliability is very high, such as in nuclear power plants and upstream and downstream oil and gas production. One of the cornerstones behind Kalsi Engineering's successes is its highly motivated staff, who boast a record of accomplishments in developing practical and cost-effective solutions to mechanical engineering problems throughout the power generation, oil field, petrochemical, defense, manufacturing, and mining industries. For an inside look at this all-round company, we spoke to its founder and president, Dr M.S. Kalsi.

Kalsi Engineering: leaders in innovative valve design, analysis and testing services

Count the number of commercial nuclear power plant reactors in the US and you'll come to one hundred and four. Now add up the number of nuclear plants that have called on the services of Kalsi Engineering and the figure will be ... one hundred and four! Without doubt, there can be no finer testimony to the high standing that Kalsi Engineering enjoys from demanding clients in the United States, or even further afield for that matter, as Kalsi Engineering's track record extends to power plants in Canada, England, France, Japan, Korea, Mexico and Switzerland. Furthermore, it also contributes to the Electric Power Research Institute (EPRI) and Nuclear Steam Supply System (NSSS) Owners' Groups. Areas of support include developing generic methodologies and solutions to address industry-wide issues, performing design basis reviews and implementing plant-wide programs related to motor-operated valves (MOVs), air-operated valves (AOVs), check valves and safety relief valves.

According to Dr Kalsi, Kalsi Engineering's reputation is also based on the fact it can offer not one, but several areas of special competence, namely valve design, analysis, testing, model development, application and problem solving. Dr Kalsi: "Our personnel have an in-depth knowledge, extensive experience and an established track record of meeting client's demands. In fact, I believe our depth, diversity and continuity of experience in addressing valve and actuator issues for nuclear power utilities over the past twenty-five years is unique in the industry."

Another special feature about Kalsi Engineering is that it can provide both analysis and testing services. "Kalsi's consulting engineering offices and testing laboratories share a common facility in the Houston metropolitan area. This environment really facilitates the development of optimum solutions based on the appropriate combination of analysis and testing," comments Dr Kalsi.

Identifying root causes

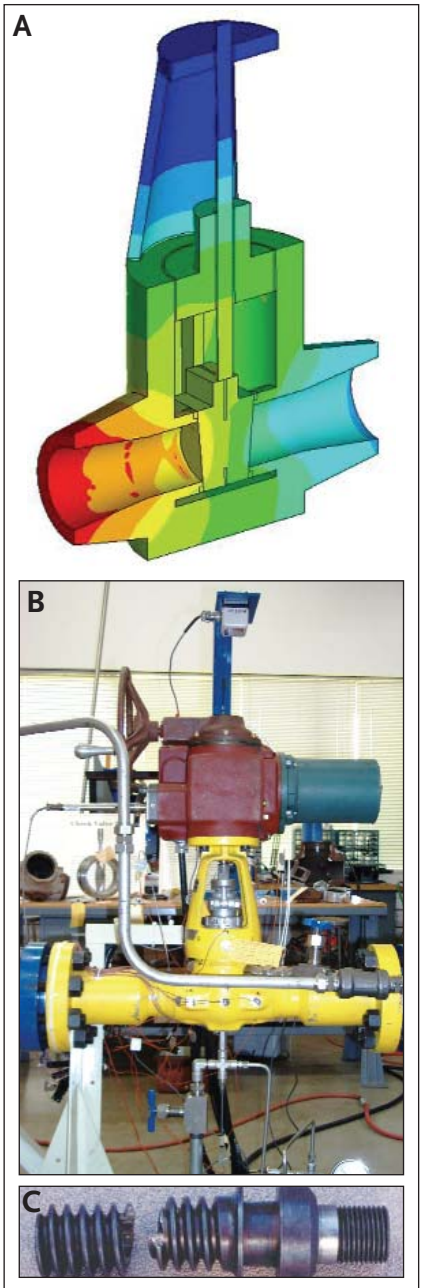
Right from its foundation, a key driver for all of Kalsi Engineering's staff has been not just to solve problems, but to understand why they occur in the first place. This information can then be used to help valve manufacturers implement design changes or to suggest operational changes to end users, thereby ensuring long, problem-free valve performance. Says Dr Kalsi: "We have applied our root cause analyses and problem-solving experiences across nuclear power plants and petrochemical plants, performing in-depth investigations of valves and actuators made by all the major manufacturers."

Asked if he could give an example of a root cause analysis, Dr Kalsi recalls work done on check valve degradation. "At one time, both the manufacturers and the plant designers worked on the assumption that these valves will be installed and operated under the ideal conditions," starts Dr Kalsi. "For

example, that the flow rate will be sufficient to fully open the disk and hold it stable. Moreover, there will not be any upstream flow disturbances. However, both of these conditions are routinely breached at most installations. As a result some valves do not perform as expected and fail prematurely ."

Before the mid 1980s, next to no research work had been performed on check valve degradation caused by disc fluttering or slamming against the stops, both known causes of fatigue and wear. That situation changed in November 1985, when Kalsi Engineering was called in to perform a root cause analysis on multiple check valve failures at a power plant in California. Dr Kalsi: "Our engineers quickly demonstrated that the problems were generic and not manufacturer specific, so we suggested opening up an additional forty or fifty different valves to document the condition of the internals. That gave us the basis for an analytical understanding of check valve degradation, and in fact kick-started an initiative which was to develop fatigue and wear degradation prediction models for check valves. This technology has been is captured in what is called CVAP, which is a check valve analysis and prioritization program."

In all, over 4,000 flow loop tests were performed on different check valve configurations allowing Kalsi Engineering to develop validated models, covering the application of valves from different manufacturers in various plant installations. This perfectly highlights Kalsi Engineering's approach - trying to find solutions that will be of benefit to all players in the nuclear industry. The overall goal is to facilitate a predictive maintenance approach, eliminating the potential for failures. Nuclear plants can therefore focus and prioritize their maintenance resources on those valves that are going to be the bad actors.



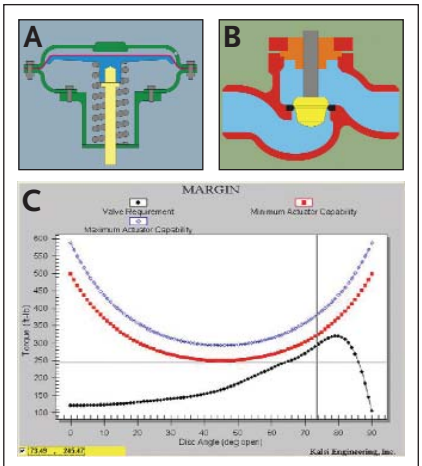
A: *Coupled FEA and CFD model of a gate vale used to resolve pressure locking and thermal binding (PLTB) concerns.*

B: *Testing to validate the predictive PLTB model*

C: *Fatigue failure of motor operator worm that is accurately predicted using LiFE™ software*

Advances in valve predictive models

Kalsi Engineering has since extended its work on degradation and predictive models to include other valve types, such as butterfly valves, safety relief valves and gate valves. One recent project that Dr Kalsi was keen to discuss concerned the development of more sophisticated validated models for air-operated valves. Dr Kalsi: "The EPRI looked at this issue

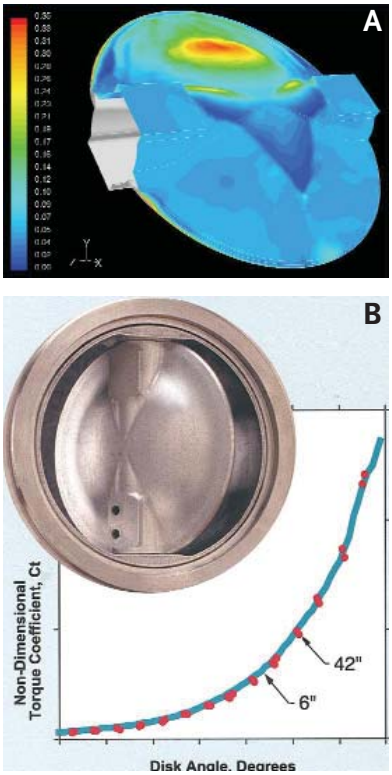


A and B: *Graphical view of an air actuator and valve taken from KVAP™ software.*

C: *KVAP™ eliminates excessive conservatism or non-conservatism found in prior industry models. In many applications this can help avoid costly air actuator replacement or modification.*

back in the 1990s, but they were more focused on motor-operated valves. We were getting strong feedback from the industry about the need for much greater accuracy in regards to air-operated valves. So we developed new models to provide bounding predictions of air operated valve performance without the excessive margins that were necessary in the previous industry models to cover the uncertainties."

In brief, Kalsi Engineering performed extensive compressible and incompressible flow testing and developed validated analytical models to accurately quantify the torque requirements for all common types of ball, butterfly, and plug valves used in nuclear power plants. The program covered manufacturers' variations in symmetric, single-, double-, and triple-offset butterfly valve designs. The new models are more accurate, and in many applications can provide a substantial increase in margins between valve requirements and actuator capabilities, thus eliminating unnecessary equipment modifications. The test program was conducted under 10CFR50 Appendix B QA requirements to develop the torque and flow coefficients, including the effect of elbows. The test matrix included over



A and B: *CFD analysis and precisely scaled model testing were performed on many different butterfly valve disc shapes to develop state-of-the-art predictive analytical models.*

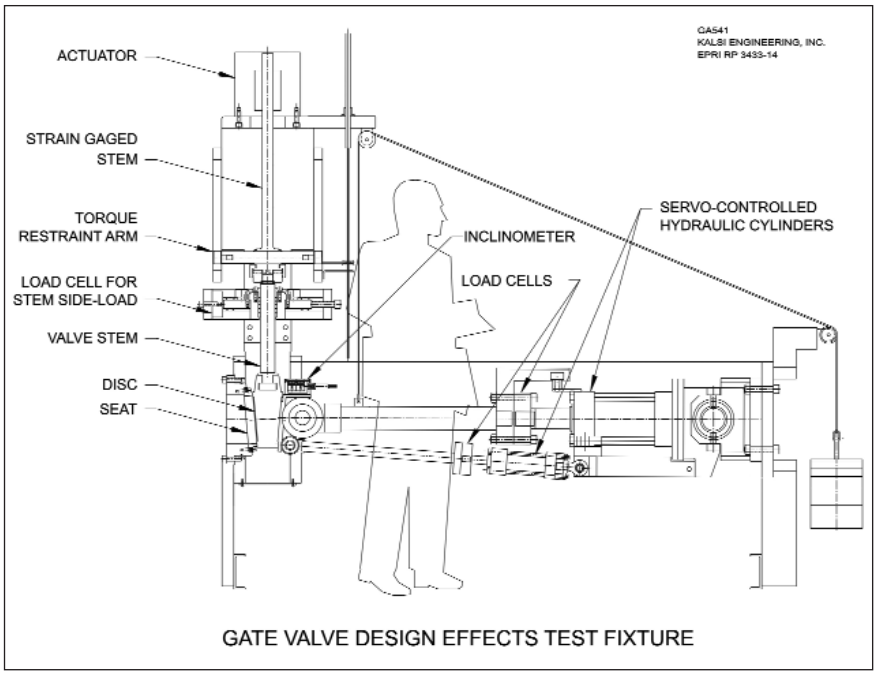
2,500 static and dynamic tests to cover variations in disc geometry, elbow orientation, elbow distance, flow direction, flow rates, and differential pressure. The validated methodologies as well as torque coefficients, flow coefficients, and elbow influence factors are incorporated in KVAP, the Kalsi Valve & Actuator Program.

Although Dr Kalsi is modest about this development program, it is quite remarkable for an independent company to have been the driving force throughout. Although it was widely accepted that a more sophisticated model would help ensure that air-operated valves would work under accident scenarios and design basis conditions, other interested parties were unable or unwilling to provide funds for the necessary research work. Dr Kalsi: "We found that even though there was interest in many of the plants to use the more accurate models, they collectively could not come up with the consensus to fund the effort. We launched off on the effort based on our own internal knowledge and conviction that it needed to be done even though we were unable to get any industry funding for this project. We funded this project ourselves and it was the largest funding project initiative that we had undertaken. Our work led to the development of new and improved state-of-the-art models to predict AOV and MOV performance, taking into consideration variations in designs from different manufacturers. I am pleased to report that the KVAP software has since been snapped up by the majority of nuclear plants across North America. Furthermore, after an extensive evaluation of all available industry software, Korea (KHNP) selected KVAP and purchased a country-wide license to cover all of their 26 nuclear power plants."

Compressible flow valve testing to precisely measure valve requirements for a variety of quarter-turn valve designs over a range of operating and installation conditions.

Innovative products

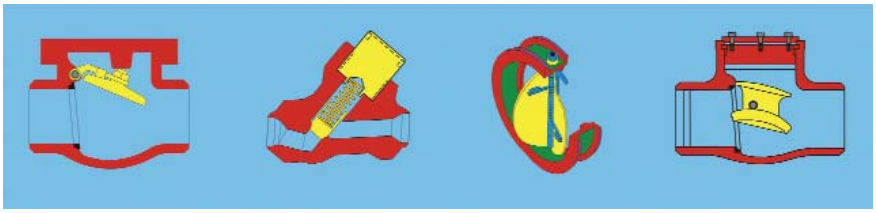
Kalsi Engineering's ability to understand the forces that can act on valves during operation has also enabled it to help improve valve designs. For example, Kalsi Engineering collaborated with GE Nuclear Energy to develop a line of gate valves for use in critical service applications in nuclear power plants. According to Dr Kalsi, these new designs have been proven to repeatedly withstand severe blowdown conditions without any degradation of performance. "The valves have been installed at several nuclear plants, including Pilgrim Nuclear Power Station, which was the utility that cooperated with Kalsi Engineering and GE in the development, testing, and installation of the improved gate valve. The new designs have accumulated a history of excellent performance for more than ten years," he concludes. So innovative are many of the features in this new valve design that Kalsi Engineering has been awarded patents covering proprietary design features. This brings the total number of patents granted to Kalsi Engineering personnel to over 35. Says Dr Kalsi: "Many patents are related to valves, with several in commercial use having been assigned to valve manufacturers, but we also have quite a few patents covering seals. In fact, we have developed innovative designs to improve seal performance so that metal to metal seals can perform and maintain their seal tightness over a wider range of temperatures."



▲ *Valve design effects test fixture used to develop a new gate valve design. The fixture faithfully simulates valve behavior in flow loops and provides inexpensive prototype testing to perfect the valve design.*

Extensive knowledge base

One of the widely recognized issues facing the valve industry at this time is the depletion of engineering skills, both amongst the end users as well as the manufacturers. Fortunately, Kalsi Engineering is ideally placed to fill the void. According to Dr Kalsi, "Firstly, we have been incorporating our learning and experience into various software packages. These are not just for design or analysis, but are also the ideal self-learning tools for others involved in valves. Superb graphical illustrations clearly help to direct the software user through the various valve designs, shapes and dimensions that influence valve performance," he stresses. Secondly, of course, Kalsi Engineering continues investing in both technology and staff, evolving its own "talent pool" for supporting the valve industry. "Without doubt, our staff is fundamental to our capacity to efficiently support valve-related projects," notes Dr Kalsi. "We recruit personnel with a strong technical background. Each of our senior key personnel have more than twenty years of experience directly related to solving problems with all types of valves. These people understand valves and how they interact with the plant's systems. They also possess an intimate understanding of internal manufacturing subtleties as well as the impacts of small design feature changes. That means we can continue to provide all our clients world-wide what they need... experience and continuity in demanding flow control applications."



▼ *Typical graphical illustrations in the Kalsi Engineering Check Valve Analysis and Prioritization (CVAP™) Software.*

Kalsi Engineering: core products and services

- Analytical models to reliably predict performance under conditions that are difficult or expensive to test
- Research and development to improve valve performance or design new valves for demanding applications
- Qualification of designs using analysis and testing to meet structural and performance specifications
- Structural integrity, fatigue life and performance qualification testing
- Friction, wear, lubrication and galling tests
- Analysis per ASME and API code requirements
- Plant-wide application reviews and development of preventive maintenance programs for MOVs, AOVs and check valves
- Valve and actuator design modifications and improvements
- Computational Fluid Dynamics (CFD) analysis and Finite Element Analysis (FEA) to quantify forces and moments on valve components
- Structural, fluid, and thermal analysis
- Mechanical and flow loop testing
- Scale model testing
- Root-cause analysis
- Training and seminars
- Independent review and assistance in utility self-assessment programs