Scheduling Replacements Smartly

Simulation is used to effectively predict crack growth that could lead to power plant valve failure.

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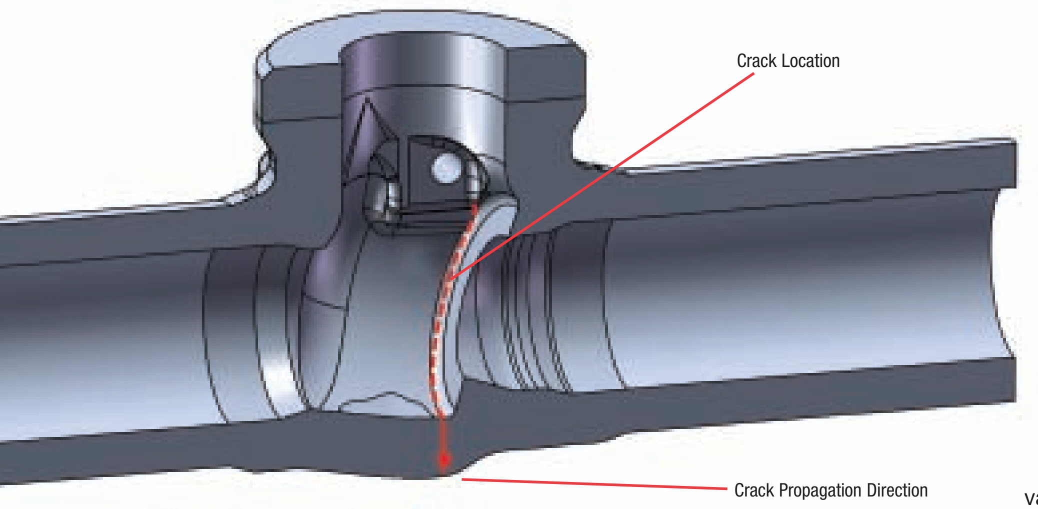


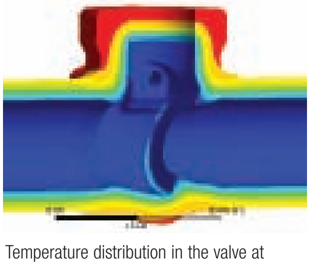
The valve model showing the location of the crack on the inner surface of the valve and the direction of propagation of the crack through the wall

The fleet of power generation equipment in the United States is of an advanced age, particularly in the case of fossil fuel plants. Many facilities have boilers, piping systems or other components that may be nearing the end of their useful lives due to damage accumulated during operation. Components susceptible to service-related damage typically are inspected to detect this damage during tightly controlled and scheduled shutdown periods, or outages. These outage schedules are often developed years in advance by the utility and have little margin for change.

Damaged components fall into two basic categories: those that are damaged but still viable for continued use and those that are in danger of failure and need to be replaced. Because part replacement is costly, it is most efficient to continue using parts as long as possible. Safety and the desire to avoid component failure that can lead to unplanned shutdowns, however, make it essential that component viability be estimated correctly.

During a scheduled outage in 2000, an inspection was performed on a check valve in use at a fossil fuel power plant in the United States. Working with the utility, Structural Integrity Associates found that the cracks circled the valve seat on the inside of the valve body. At that time, they attributed the cracks to thermal fatigue, although creep was always a concern for components, such as this valve, that operate at temperatures of 1,000 degrees F or higher. Structural Integrity worked together with the utility to measure crack depths in order to allow for monitoring of damage progression during future shutdown inspections.

Subsequently, the analysis team agreed to re-inspect the valve body during an upcoming outage scheduled for 2007. For this later shutdown, the inspection included examining the valve for further cracking, incorporating those findings into a simulation designed to predict future deterioration, and, in a short turnaround time, determining if the valve was suitable for continued service with or without repairs.



Temperature distribution in the valve at 532 seconds into a transient analysis of the valve behavior during a shutdown event

The first steps involved creating a computer model of the valve using SolidWorks®, which was completed in expectation of the 2007 outage. The developers of the model created and designated its features, based on a drawing of the valve geometry, such that one could modify them in the future to match the actual measurements found during inspection.

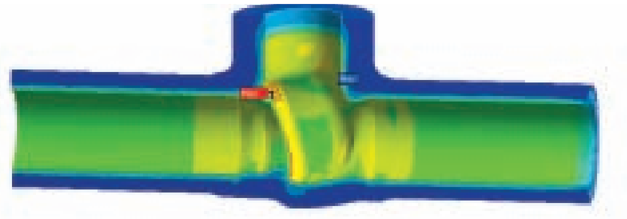
Structural Integrity used Creep-FatiguePro® — software developed for the Electric Power Research Institute — to perform a crack growth analysis. As part of this analysis, the Structural Integrity team needed to understand both the pressure stresses experienced by the valve during standard operation and the thermal stresses experienced during the shutdown process.

Due to the desire to keep shutdown time as short as possible, the team set up static and transient stress analyses prior to the actual outage using the ANSYS Workbench framework and the SolidWorks model that had been created. The ANSYS Workbench 11.0 environment was helpful in that it would later provide a seamless and fast interface for updating the model and the analysis in the field based on actual "as cast" dimensions.

The team used the ANSYS Workbench platform to run the complete transient thermal analysis coupled with a multi-step static stress analysis. To obtain stresses along a path, the switch to the traditional ANSYS Mechanical interface still had to be made, but it was easily automated, with the file structure in the ANSYS Workbench environment making this process much easier than in prior versions.

The transient thermal stress analysis used a convective condition applied to the internal surface and a step temperature change to model the shutdown event. A multi-step static thermal stress analysis was then run to determine the stresses based on the temperature distribution at various points in time.

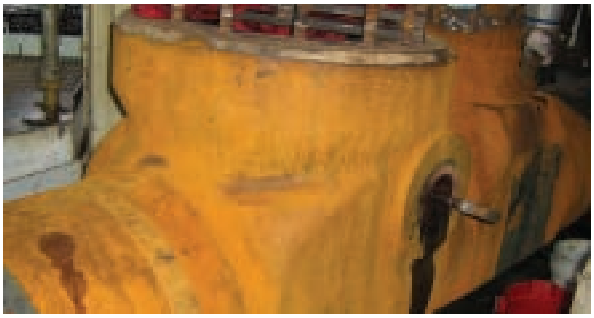
The pressure and thermal stresses then were normalized using stress transfer functions and were used as inputs into the crack growth software. The calculation of creep and fatigue crack growth is not a trivial concept. It was handled without difficulty, however, with Creep-Fatigue PRO software and the ANSYS Workbench environment, which was able to export stress analysis results that could easily be used to generate the input to the crack growth software.



Stress distribution in the valve at 532 seconds into a transient analysis of the valve behavior during a shutdown event

Structural Integrity used this methodology, beginning with the measurements taken in 2000, to study the advance of the crack propagation between 2000 and 2007. They compared these results to measurement data acquired in 2007. There was good correlation between the simulation predictions and the measured data, validating the prediction process.

By using this methodology to then analyze the valve for further use, analysis results showed that an expensive replacement of the valve was not immediately needed. The crack growth rates in this valve were low, and the valve could be operated safely potentially for many more years with continued monitoring of the valve at future outages. The crack growth model will be updated with ongoing plant operational data to provide a continuing picture of the crack growth rates for the future. The client was able to make decisions quickly during the outage because the analysis was completed within two days of the completion of the valve inspection, thereby minimizing the length of the outage and avoiding an extremely expensive replacement of the valve. ■



Outside of the valve

Internal view of the valve