framatome

XEDOR Cladding Stress Monitoring

Risk-informed PCI management

Knowledge is literally power when it means you can increase the capacity factor of your BWR. XEDOR delivers the knowledge needed to improve the efficiency of necessary power maneuvers by minimizing execution time and total lost generation.

Challenge

Adjustments in the control rod patterns used to manage reactivity in your BWR are a necessary part of your operations strategy. Withdrawal of a control blade results in a surge in local power causing the temperature of nearby fuel pellets to rapidly increase. If power is increased too fast, any gap between the pellet and cladding can close and the cladding can be subjected to stresses above failure thresholds.

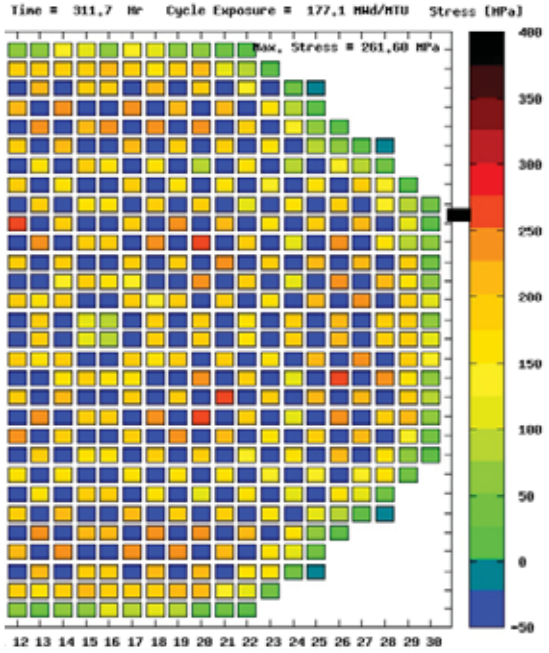
If the operator can be provided with accurate information on the mechanical condition of the fuel at the time of a power change, a more optimal maneuver can be designed and executed. However, maintaining real-time information on the mechanical state of each fuel rod in the core is a major computational challenge, requiring up to two million individual calculations each time an update is executed.

Solution

For the first time ever, real-time data on the mechanical state of the fuel can be calculated with Framatome's XEDOR Pellet-Clad Interaction (PCI) management tool. A rigorously validated reduced-order computational model tracks the changes in the dimensions of fuel pellets and cladding over the life of the fuel. This model can be rapidly executed with mid-level processors to allow a full core update to be executed in under 30 seconds.

The impact of a planned control sequence change can then be accurately predicted, providing reactor engineers with the knowledge needed to optimally design the maneuver. The end result is assurance of a consistent margin to the failure stress threshold while recovering generation capacity that would be lost when relying on preceding empirically based maneuvering guidelines.

XEDOR has been integrated into Framatome's core monitoring software system, POWERPLEX-XD, to provide a complete core management system for reactor engineers and operators.

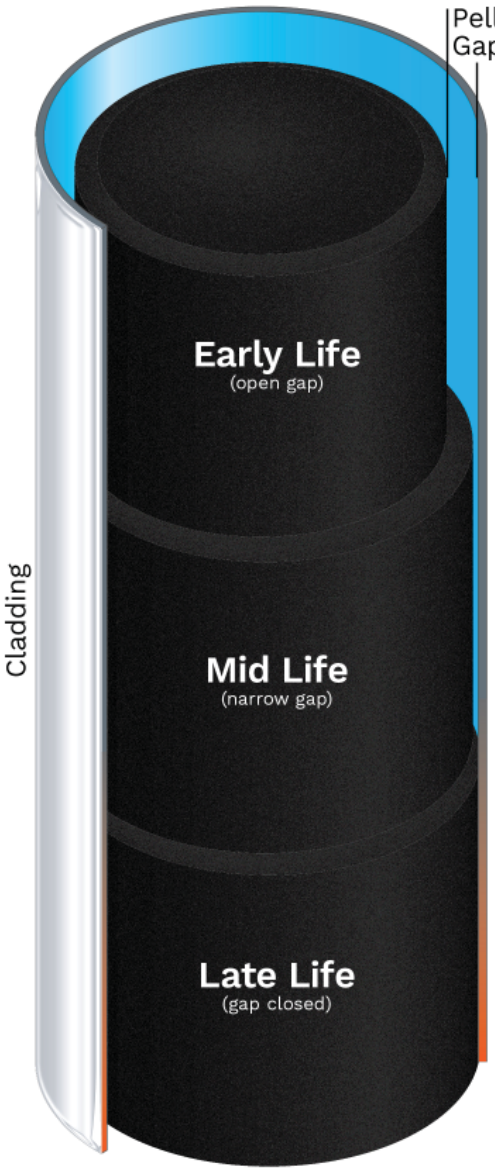


XEDOR can execute a full core stress survey in less than 30 seconds

Customer benefits

- Real-time online monitoring of fuel rod mechanical state
- Tracking of every 6-inch segment of every fuel rod in the core
- Consistent minimum margin to cladding stress limits
- Increased plant capacity factors
- Explicit modeling of each fuel type in the core, regardless of supplier
- No surprises when operations diverge from past experience

Your performance
is **our** everyday **commitment**



Fuel Pellet Early Life
Cladding creepdown and pellet swelling will gradually close initial pellet-to-clad gap.

Power ramps will not raise stress until gap is small enough to be bridged by thermal expansion.

Fuel Pellet Mid Life
No increased cladding stress during a power ramp until thermal expansion closes gap.

Continued power increase after gap closure directly raises cladding stress.

Fuel Pellet Late Life
Pellet-Cladding Interaction (PCI) during a rapid power ramp immediately raises cladding stress.

Cladding creep relaxation will condition fuel to new power level over time.

References

- "Eyeing PCI on the fly" Framatome has developed a new type of power maneuvering software which works in conjunction with the normal core monitoring code to calculate the stresses imposed on fuel rod cladding by a uranium pellet expanding with increasing temperature.
- "B. Ralph Sylvia Best of the Best Award — Tennessee Valley Authority employees at Browns Ferry Nuclear Plant have been honored with the Best of the Best Award for its 'Improved Fuel Conditioning Monitoring with XEDOR.'"

XEDOR accurately models all stages in the dimensional evolution of a fuel rod over its operational life and can model fuel provided by any BWR supplier

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