Modeling of Boiling Water Reactors

Information Systems Laboratories, Inc.

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Organization

BWR Modeling and Model Assessment Session Agenda

1. Model Overview
2. Determining Key Analysis Parameters
3. Important BWR Phenomena
4. BWR Specific Components
5. Steady State Model
6. LBLOCA Simulation

Steady State

The PIRT identifies several phenomena which play an important role in determining PCT. While each phenomenon can be examined independently to determine the model parameters that are necessary to effectively capture that particular phenomenon, many of the important phenomena are related to the quantity and motion of fluid and vapor throughout the system.

Realistic representation of several of the important phenomena depend on achieving good steady state conditions for:

- Flow rates
- Flow resistances (K losses and wall friction)
- Thermodynamic properties (Pressure, Temperature, void)

BWR Model Control Systems

In BWR systems, typical steady state targets include:

- Core Mass Flow
- Core Inlet Subcooling
- Downcomer Level
- Pressure at the Turbine Stop Valve & Steam Dome

Steady State Challenge

To achieve steady-state there are typically several target conditions that need to be reached simultaneously.
(e.g. Loop flows, Dome pressure, Downcomer level, etc.)

Adjusting parameters to reach one target can affect other steady state values.

How do you efficiently achieve all steady state target conditions?

- Control Systems

Control System Options

As discussed in the PWR session, there are two primary options for steady state control systems in TRACE:

- Constrained Steady State (CSS) Controllers

  TRACE includes prebuilt steady state controllers for achieving certain common steady state values such as pump flows or target pressures at a valve. Recently, the ability to control K losses to achieve target pressure drops was added. CSS controllers are fairly easy to add and configure.

- User Defined Control Systems

Constrained Steady-State Controllers

There are five types of CSS controllers that can be used:

1. Type 1 Controller: Adjust PUMP rotational speed to match a user desired mass flow rate.
2. Type 2 Controller: Adjust VALVE flow-area fraction to match a desired upstream pressure or mass flow rate.
3. Type 3 Controller: Adjust FILL mass flow rate to match a desired mass flow rate at some other location in the input model.
4. Type 4 Controller: Adjust HTSTR heat transfer area or thermal conductivity or heat transfer coefficient multipliers or the hydraulic-channel pressure associated with the HTSTR surface to match a single-phase coolant temperature or void fraction.
5. Type 5 Controller: Adjust additive flow loss factors to match a user desired steady-state pressure drop.

The CSS types that are most commonly used are Types 1, 2, and 5.

The type 1 and 2 CSS controllers were discussed earlier in the PWR model presentation and exercise.

Constrained Steady-State Controllers

The object of this next exercise is to add controllers to achieve good steady conditions in the BWR system. The exercise is divided into two parts:

- Part 1 adds controllers to achieve target steam dome and steam line pressures.
- Part 2 adds a controller to achieve the target core mass flow rate.

Question: How does setting the system pressure and core mass flow affect other steady-state target values?

Exercise

Follow the instructions outlined in the **Add Constrained Steady State Controllers** exercise (BWR-5-Exercise-CSS.pdf). This exercise applies a CSS controller to achieve the pressure drop across the turbine control valve to yield a pressure upstream of the valve of 5.4 MPa. It also applies a CSS controller to adjust the flow loss in the steam line to achieve a target steam dome pressure of 6.8 MPa.