Add Constrained Steady State Controllers

Objective

Steady State can be achieved most efficiently by including control systems that bring the system into line with steady state targets. For convenience, TRACE includes a few built in steady state controllers that can be configured relatively quickly. The built in controllers are called Constrained Steady State (CSS) controllers. Note that CSS controllers ONLY work during steady state mode, so they are not appropriate for control systems that must be active during a transient event.

The objective of this exercise is to implement two CSS controllers in the example BWR model. There are five CSS controllers available to the user. In this exercise, CSS controller types 2 and 5 will be used to adjust the turbine stop valve (TSV) area to obtain the pressure upstream of the valve face (type 2) and to adjust the flow loss in the steam line to obtain the target steam dome pressure (type 5).

> The Pressure Controller is really a differential pressure (dP) controller. It adjusts K losses at a specified edge in order to achieve a dP across two cells that are also specified.

Setup

You can either continue with the model from the previous exercise, or open the SNAP model named 'PBTT_SS5.med' in the folder 'Day4\Afternoon\BWR\' under the workshop main folder.

Review the Steady State Simulation

Before adding the CSS controllers, review the steady state values for TSV pressure and steam dome pressure recorded from the previous exercise. How close are the actual values to the target values? At present no control systems are present to set these pressures.

Adding a CSS Valve Controller (For Pressure)

One of the Constrained Steady State controllers that is simple to include is a controller that **controls a valve face area in order to achieve a fixed pressure** in the cell just upstream of the valve. One place where this is useful is at the turbine. For this exercise, a CSS is applied to **VALVE 55 (TSV)** with an upstream target pressure of 6.4 MPa.

Add a TSV CSS controller:

1. Enable the constrained steady-state mode.

   a) Locate "Model Options" in the Navigator Window.

   b) In the Properties Window assure the model is set to run in a steady-state mode and

   c) Select the CSS Calculation in the Steady-State Model box.

> Constrained Steady State controllers can only be added in SNAP when a model is running in the Constrained Steady State mode.

   d) Locate and Expand the 'Constrained Steady State' dialog box and add a CSS controller.

2. Configure the 'CSS Controller: 1':

   a) Change the CSS controller type to a valve controller.

   b) The adjusted component needs to be the TSV.

   c) The Min and Max adjusted values indicate the range the valve area can modulate. These values are input in terms of the fraction of the valve area. For this exercise, it is assumed the TSV cannot modulate any more than fully open or fully closed.

d) Complete the input for the CSS by entering the target pressure setpoint.

Adding a CSS Pressure Controller

The CSS pressure controller adjusts the K loss at a user specified cell edge in the model in order to achieve a user defined **pressure drop (dP)** between two cells (pressure tap cells) specified by the user. Cells do not need to be adjacent to each other nor do the need to be in the same component where the K loss is controlled.

Vessel cells can be used as pressure tap cells in the Pressure Controller, if the namelist variable 'CSS Max Number' is set to **True**. This option causes CSS controllers to use long names for specifying values such as component numbers. Long names are needed to support selection of vessel cells.

There are various cases where the pressure drop through a section of the plant is specified. The CSS K Loss pressure controller is a good option to use for achieving target pressure losses through sections of the model.

For this exercise, the CSS pressure drop is monitored between the upstream side of the TSV (**VALVE 55**) and the VESSEL steam dome (**level 19**). The pressure in the steam dome of the VESSEL component is monitored. The target steam dome pressure is noted as 6.8 MPa. The k-loss in the steam line (PIPE 100, cell face 3) will be adjusted (using the CSS controller) to achieve the pressure drop in the steam line to achieve the target steam dome pressure.

The first part of this exercise set the pressure at the turbine stop valve 6.4 MPa. The target steam dome pressure is 6.8 MPa. The pressure drop (dP) from the steam dome to the TSV is 0.4 MPa or 4e5 Pa. We will add CSS Pressure Controller with a target dP of 0.4 Mpa.

1. Locate and Expand the 'Constrained Steady State' dialog box located under 'Model Options' and add another CSS controller.

2. Configure the 'CSS Controller: 2':

   a) Change the CSS controller type to a pressure controller.

   b) The adjusted component is the location where the k-loss is adjusted in the modeled steam line (PIPE 100, cell face 3). Make this change to the CSS controller.

   c) Note that for this case, the "Max Adjusted Value" is the target dP (0.4 Mpa). Set the target dP.

   d) Set the 'Min Adjusted Value' to **0.2**.

Note that in SNAP the Min and Max Adjusted Value properties are generically used in all of the CSS controllers. The name Min and Max may not necessarily reflect the actual values of the input as it is in the case of the pressure controller. For the pressure controller, the 'Max Adjusted Value' is really the target dP and the 'Min Adjusted Value' is the order of magnitude to adjust the K loss value.

The 'Monitored Parameter' and 'Adjusted Parameter' are also generically used in the CSS controller input in SNAP. For the CSS Pressure Controller, the 'Monitored Parameter' is the cell with the higher pressure value, and the 'Adjusted Parameter' is the cell with the lower pressure value.

   e) Set the 'Monitored' and 'Adjusted' Parameters in the CSS controller for the dP calculation.

Valve 55 cell 1 is the TSV cell where pressure is being controlled in the first CSS controller, to reach 6.4 MPa in the cell. In the second CSS controller, we used a dP of 0.4 MPa (between the Valve 55 cell 1 and the steam dome), so the steam dome pressure should reach 6.4 + 0.4 = **6.8 MPa**.

Run the Steady State Simulation

Rerun a steady state simulation by doing the following:

1. Save the SNAP model as PBTT-SS5a-Ex5.med.
2. Submit the steady state simulation using the Job Stream View tab located at the bottom of the View Window in the Model Editor.
   a) Click on the Execute button and change the name to reflect this exercise (for example BWR-Steady_State-ex4). Note that changing the name of the SNAP job submission will not over-write the calculations made previously.
   b) Click on the lock button in the upper left-hand corner of the View window and then click on the Execute button to submit the job.

From the animation window review the steady state target values again. Did any values change significantly?

Parameter	Target/Expected Value	Actual Value
Turbine Stop Valve Pressure		Old: New:
Steam Dome Pressure		Old: New:
Downcomer Level		Old: New:
Core Mass Flow		Old: New:
Total Jet Pump Mass Flow	None Given	Old: New:
Core Inlet Temperature		Old: New:

Parameter	Target/Expected Value	Actual Value
Feedwater Flow	None Given	Old: New:
Steam Line Flow	None Given	Old: New:

Conclusion

One disadvantage of the CSS controllers is that there is very little that you can configure about the controller, so there are few options for optimizing performance. In addition, there are a fairly limited number of control cases that can be handled via CSS controllers. User defined control systems provide more control and flexibility and can be used to control a larger variety of components, but are more complicated to develop and maintain. TRACE does include the PI controller component which does make the process of adding a custom controller fairly simple.