Initial Gain Stability Estimate Exercise

Objectives

Use the unit step technique to estimate the initial PI controller proportional gain.

Preliminary Setup (Open Model)

Open the 'Day3\Afternoon\PWR2_Achieving_Steady-State\' folder and double click on 'PWR2-SS2.med' if your model is not current.

Create a New Turbine Control Valve Controller

In the PWR model, the turbine control valve area is used to control the average temperature across the steam generators (T_{av}). The turbine control value area directly affects the secondary side pressure. The secondary side pressure sets the saturation temperature in the boiler region. The saturation temperature in the boiling region, in combination with the system power and heat structure material properties, sets T_{av} .

To estimate the initial PI controller gain for the turbine control value area controller, we need to determine how much T_{av} changes for a specific change in the valve area. Do the following:

1. In the `Hydro Comps` tab, find the turbine control valve (Valve 550). You can use the find diaglog (`Edit` → `Find`) and sort the components by number.
2. Select Valve 550 and find the `Valve Table Indep. Var.` property. Note that the `Flow Area Adjustment Type` property is set to **[0] Flow Area Fraction per Second**. Thus control block -511 is used to control the valve area.
3. Go to the `Control System` tab and find control block -511. Again the find dialog is useful.
4. Add a `Function` control block (type 102) above control block -511 and number

it as -512.

5. Connect the time signal variable to the input of control block -512. You can either use the time signal that is currently in the view (signal variable 1) or add a new time signal to the control view.
6. Set the `Function Table` for control block -512. Add 2 rows with times 0 and 1e6 as time times. Set the table values to 0.1 (i.e., a value that is 10% open).
7. Go to the `Hydro Comps` view and select the turbine control valve (Valve 550) and change the Valve Table Indep. Var. from -511 to -512.
8. Select `Model Options` in the Navigator Window. Find the `Timestep Data`, and set the `End Time` for the simulation to 400 seconds.
9. Go to the `Job Stream` tab and `Execute` the model.
10. Go to the PWR2-Anim animation file. Open the `Steady State Plots` tab and examine the T_{ave} control response. Note that this takes about 120 seconds to reach steady state.

Add a Step Function

Now that we know how long it takes the system to come to steady state, lets adjust the controller to add a step function.

1. In the PWR model, go to the `Control System` tab and select control block -512. Open the `Function Table` and add two more rows. Set the table to the following values.

Time (s)	No Unit
0.0	0.1
150.0	0.1
150.001	0.3
1e6	0.3

2. From the `Job Stream` tab `Execute` the model. If you would like, you can go to the animation file, connect to the simulation and watch the T_{ave} results.
3. Allow the simulation to run to completion then open the simulation in Aptplot. You can do this quickly from the Job Status window by clicking the AptPlot icon on the tab that shows the simulation output.
4. If the TRACE data dialog does not open in AptPlot, open it via the 'Edit→Edit plug-in data→TRACE data' menu item.
5. Plot control block 108 (cb108) which is the T_{ave} value for loop 1 and fill in the table values below where A_f is the valve area fraction. Note that you can bring up a table of the plotted values by double clicking on the data set 'G0.S0' in the TRACE data dialog:

Time (s)	A_f	T_{ave} **(K)**
150	0.1	
400	0.3	

6. Calculate the slope $\Delta A_f / T_{ave}$. The negative of this is an initial estimate of the stability limit for the proportional gain G_p. The stability limit is used in the Zeigler-Nichols method for determining PI controller gains. Note the value. This will be used in the next exercise.

$G_p =$

Reconnect the PI Controller

Now we need to reconnect the turbine control valve to the original PI controller.

1. Go to the `Hydro Comps` tab and select the turbine control valve (Valve 550).
2. Set the `Valve Table Indep. Var.` to -511.