PID Controller Exercise

Objectives

- Use the Zeigler-Nichols method to tune a PID controller

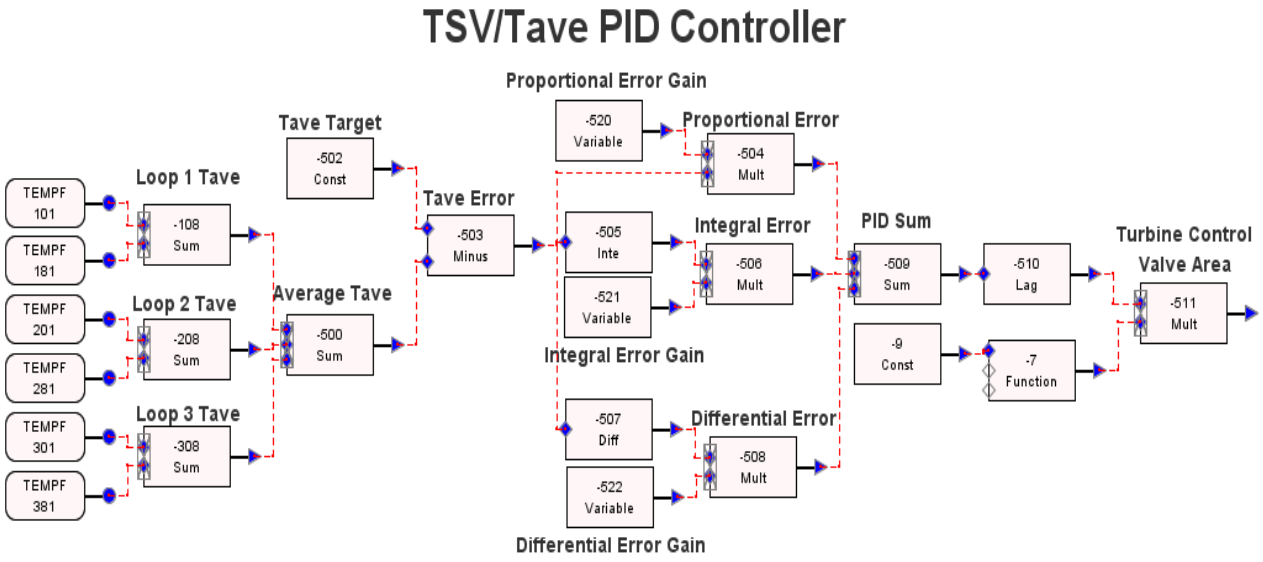
Preliminary Setup (Open Model)

Close all previous SNAP Model Editor files.

Open the 'Day4\Morning\PWR2_Achieving_Steady-State\' folder and double click on 'PWR2-SS2.med'.

Determine Zeigler-Nichols Coefficients

A loop average temperature (Tave) controller has been included in the PWR model, which adjusts the turbine stop valve area in order to set the secondary side pressure. The secondary side pressure determines the secondary side boiling point which strongly influences Tave.

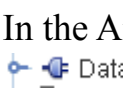


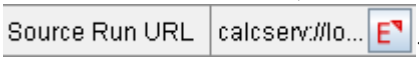
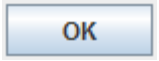
In accordance with the Zeigler-Nichols method, the integral and differential gains have been set to zero, and the proportional gain has been set such that the Tave response is oscillatory with approximately constant amplitude (i.e. GPMax=0.055).

1. Run a 100 second steady-state. View the Tave response using the animation file to approximate the oscillation period.

a) The timestep input data has been set up to run a 100 second steady-state calculation. Locate and click on the "Job Stream" tab at the bottom of the View Window. A job stream has already been set up for this exercise. To submit the job, lock the View Window by clicking on the padlock icon located at the left-hand side in the Toolbar then click on the "Execute" button in the View Window. The Job Status window will appear and the job should be running.

b) Go to the folder 'Day4\Morning\PWR2_Achieving_Steady-State\' and double click on the file 'PWR2-SS2-Anim.med'. This will open the animation file for the exercise.

c) In the Animation Model Editor Navigator Window, click on  from to expand the data sources list.

d) Click on  , and in the Properties Window expand  . In the 'Select Data Source' dialog, expand the 'local' box, select 'PWR2-SS2', and from the list pick 'PWR-SS2:trcxtv' (this is the graphics files that will drive the animation). Click  .

e) From the icons in the Main Tool Bar at the top of the screen select  to connect to the TRACE simulation chosen in the previous step to the animation screen. If the animation successfully connects, the icon should change to  .

f) Select the play icon  to start the animation.

g) Examine the 'Tave' Plot. Has the solution converged on the target value (576 K)? From the Tave plot we see that the oscillation period (TP) is approximately 18 seconds.

2. Calculate the P, PI, and PID controller gains for the Zeigler-Nichols method based on the oscillation period TP (18 s) and GPMax (0.055) in the table below:

Controller Type	GP	GI	GD
P Controller	GP = ½*GPMax =	GI=0	GD=0
PI Controller	GP = 0.45*GPMax =	GI = 1.2*GPMax/TP =	GD=0
PID Controller	GP = 0.6*GPMax =	GI = 2*GPMax/TP =	GD = TP*GPMax/8 =

The next few steps will examine the response of the Tave controller by changing the gains calculated for the PI and PID controllers.

3. Go to the PWR2-SS2 Model Editor file and reset the end time to 1.0e6 seconds.

a) In the Navigator Window, click on Model Options. In the Properties Window, locate and expand the "Timestep Data" dialog box 

. Change the "End Time" to 1.0e6 then click the OK button.

b) Submit the job for execution (see Step 1a). Note that the View Window is already locked.

c) Connect the animation to the calculation using Steps 1e and 1f.

d) The same Tave response should be displayed.

4. After the calculation has run for about 100 seconds, interactively change the gains calculated for the **PI** controller (see GP, GI and GD calculated in the table above) in the animation. Make these changes in the boxes provided on the Animation Screen (pressing the enter key on the keyboard after each change).

a) In the box next to **P Gain (GP):** input the calculated value for **GP in the PI row**. Press the enter key.

b) In the box next to **I Gain (GI):** input the calculated value for **GI in the PI row**.
c) In the box next to **D Gain (GD):** input the calculated value for **GD in the PI row**.
d) Note the change in the Tave response. How has the Tave been affected by the change in the PI controller gains? Is the average temperature getting closer to the target value?

5. After the calculation has run for an additional 100 seconds, interactively change the gains calculated for the **PID** controller (GP, GI and GD calculated in the table above) in the animation (refer to Steps 4a through 4c). Note the Tave response with the PID controller gains. How has the Tave been affected by the change in the PID controller gains? Is the average temperature getting closer to the target value?

6. Adjust the gain values from the 'Tave Control' tab in the animation. See if you can improve the setting time using the guidelines from the presentation.

Assuming the sign of the gains is correct, and that a lag control of Gain 1 and Lag constant CL is added to the PID output, the typical effect of increasing $|GP|$, $|GI|$, $|GD|$, and CL is summarized in the Table below:

	Rise Time	Overshoot	Settling Time	S-S Error	Noise
$\|GP\|$	Reduce	Increase*	-	Increase	-
$\|GI\|$	Reduce	Increase*	Reduce or Increase*	Remove	-
$\|GD\|$	-	Reduce*	Reduce	-	Increase
CL	Increase	Reduce*	Increase or Reduce*	-	Reduce

* When over-correction occurs signaled by oscillations

7. When you are finished, stop the calculation by clicking on the  button in the "Job Status" window.