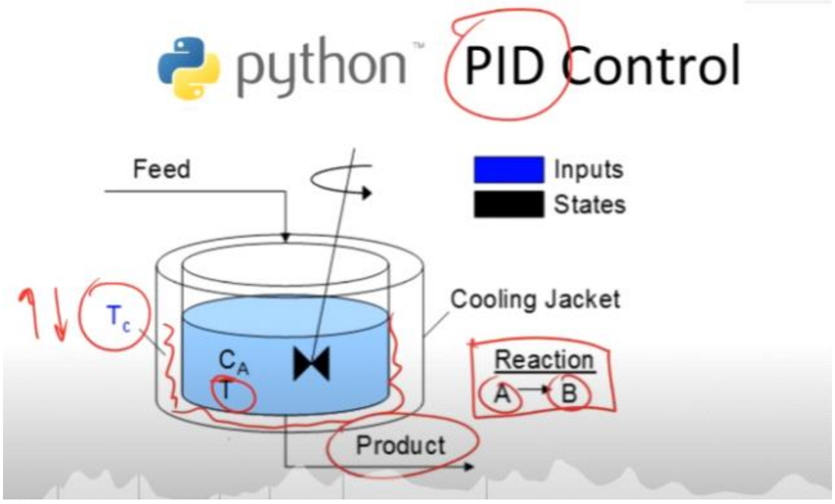
PID controller Chemical reactor practice

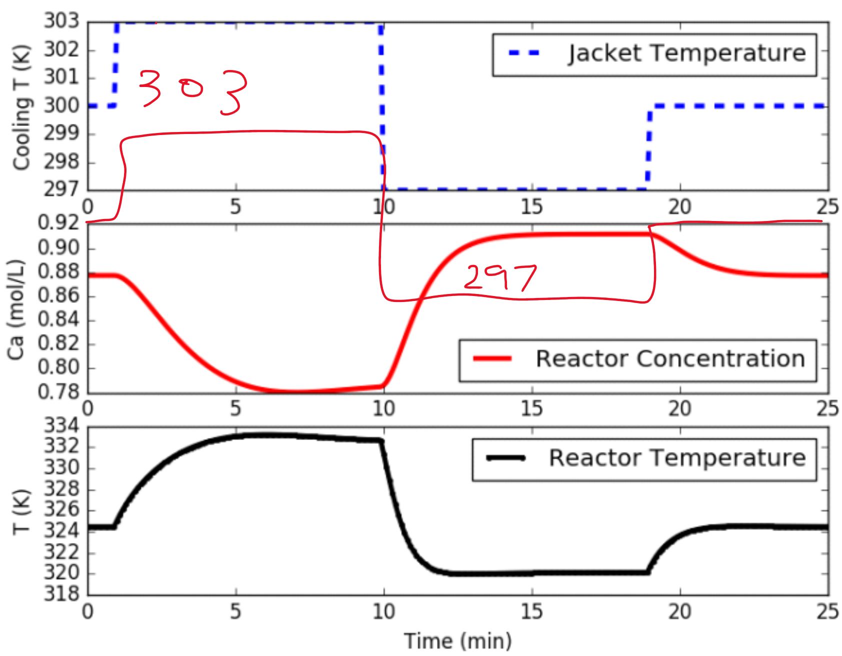
April 11, 2024 12:49 PM



Goal: manipulate the temperature of the cooling jacket that cools off the reactor

notes:

Exothermic reaction of reactant A to product B, want to tightly control the T to make the right concentration of B



300 Double Test

Steps: fit a model (dynamic) to help get PID tuning parameters

- First order plus dead time model

FOPDT

- $$\boxed{\tau \frac{dy}{dt} = -y + K u(t - \theta_p)}$$

- Controller gain, integral time constant, and derivative time constant

$$T_c = \overset{(300K)}{T_{co}} + \overset{\boxed{P}}{K_c}\overbrace{(SP - T)}^{e(t)} + \overset{\boxed{I}}{\underbrace{\frac{K_c}{\tau_I}\int_0^t (SP - T)dt}_{\text{Integral}}} - \overset{\boxed{D}}{K_c \tau_D \frac{dT}{dt}}$$

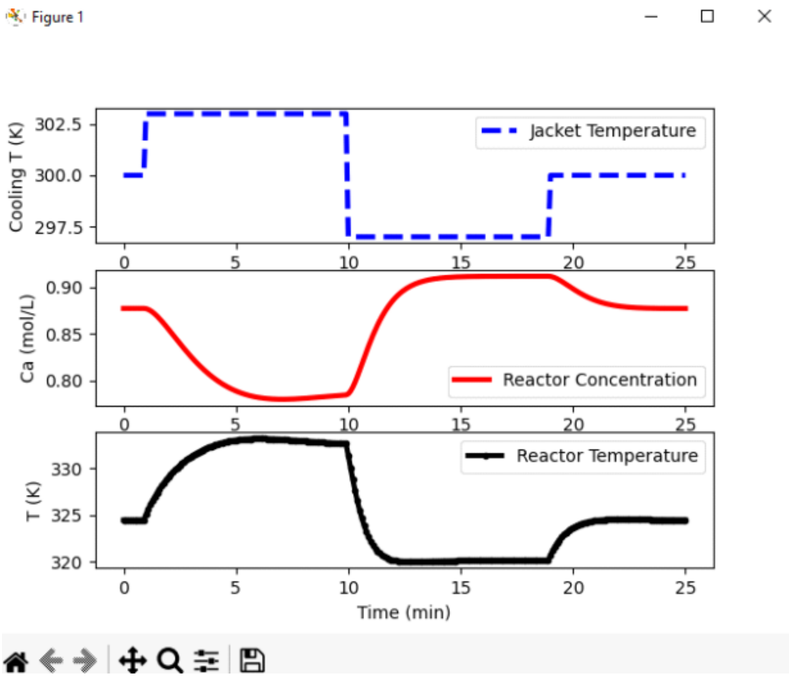
P, I and D can be adjusted to control how much weighting is given to the proportional integral and the derivative

Snippet of data file:

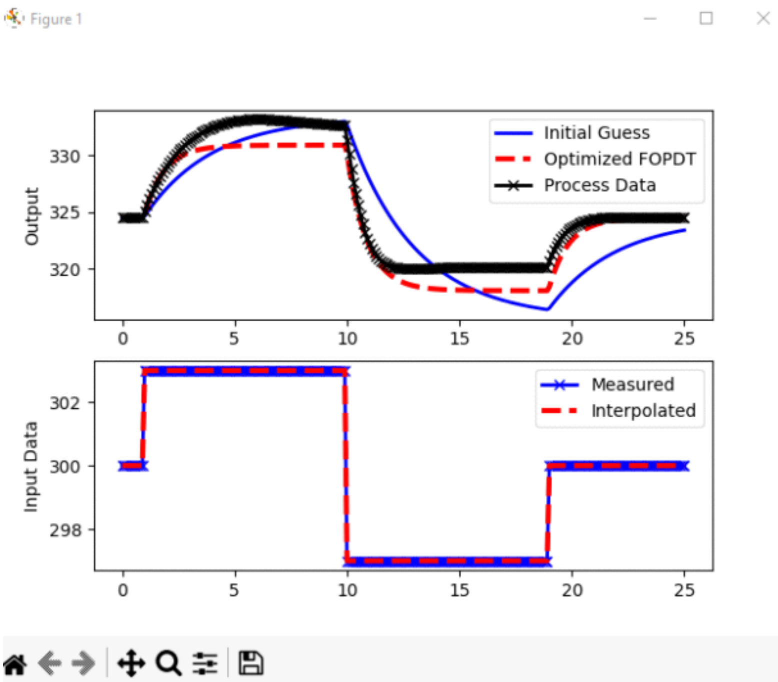
```
ata_doublet.txt
0.000000000000000000e+00,3.000000000000000000e+02,3.244754434315989897e+02
1.000000000000000056e-01,3.000000000000000000e+02,3.244754434315989897e+02
2.000000000000000111e-01,3.000000000000000000e+02,3.244754434315989897e+02
3.000000000000000444e-01,3.000000000000000000e+02,3.244754434315989897e+02
4.000000000000000222e-01,3.000000000000000000e+02,3.244754434315989897e+02
5.000000000000000000e-01,3.000000000000000000e+02,3.244754434315989897e+02
6.000000000000000888e-01,3.000000000000000000e+02,3.244754434315989897e+02
7.000000000000000666e-01,3.000000000000000000e+02,3.244754434315989897e+02
8.000000000000000444e-01,3.000000000000000000e+02,3.244754434315989897e+02
9.000000000000000222e-01,3.000000000000000000e+02,3.244754434315989897e+02
1.000000000000000000e+00,3.030000000000000000e+02,3.250746210002531029e+02
1.100000000000000089e+00,3.030000000000000000e+02,3.256227109949379610e+02
1.200000000000000178e+00,3.030000000000000000e+02,3.261270116683274978e+02
1.300000000000000044e+00,3.030000000000000000e+02,3.265933474626003203e+02
```

First column is time, second column is cooling jacket T, and third column is the reactor T

Initial data:



After fit:



This will create fit to data that can give some PID tuning parameters

Note:

Initial SSE Objective: 1803.5188706212914
Final SSE Objective: 588.7797064755933
Kp: 2.1460694665234756
taup: 0.8845555141722596

thetap: 3.838241516133893e-05

Use these values for the next step

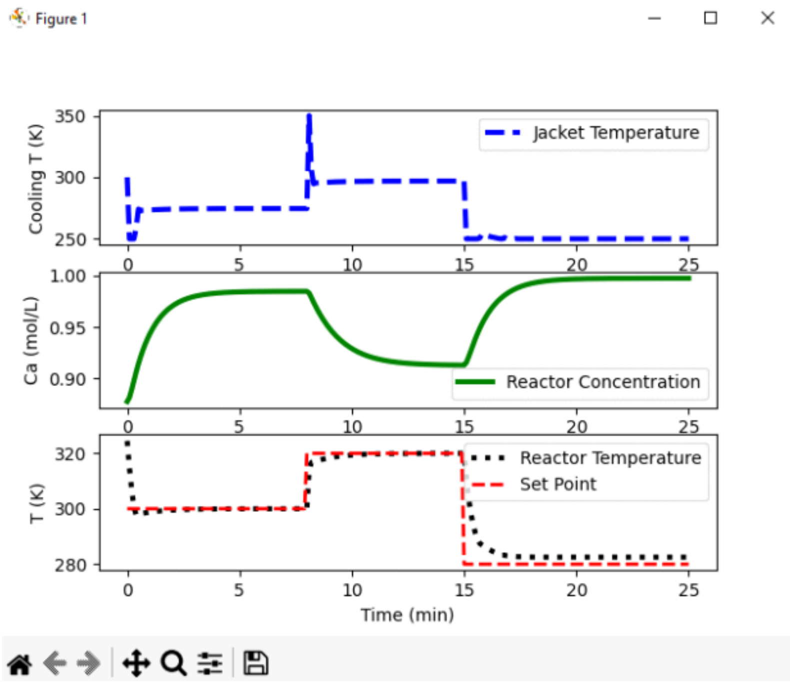
$$\boxed{\tau \frac{dy}{dt} = -y + K u(t-\theta_p)}$$

Use Internal Model Control (IMC) tuning correlation

Proportional integral design:

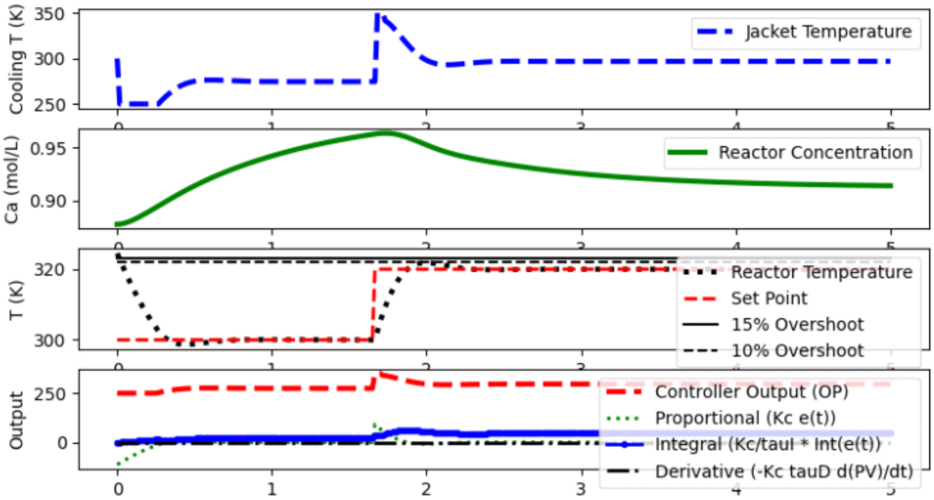
Kc: 4.617306151813776
tauI: 0.913444964569

Default obtained from fitting data(this will implement PID controller with IMC)



Comments: (look set point line) starts at 300, went up 320, then back down to 280. The jacket temperature does not reach the set point because it reaches a lower bound of 250, it cannot go any lower, so the reactor cannot go any lower than about 280 (reactor and jacket T are proportional)

Improved tuning:



Comments:

In the third graph, the reactor T makes a step up about 10% overshoot then it levels up

In the fourth graph, it is the PID controller (red dashed line is the output). Making corrections

Sources:

https://apmonitor.com/do/index.php/Main/NonlinearControl