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GIVEN:
A SISO process Simulink file and the disturbance is measurable.

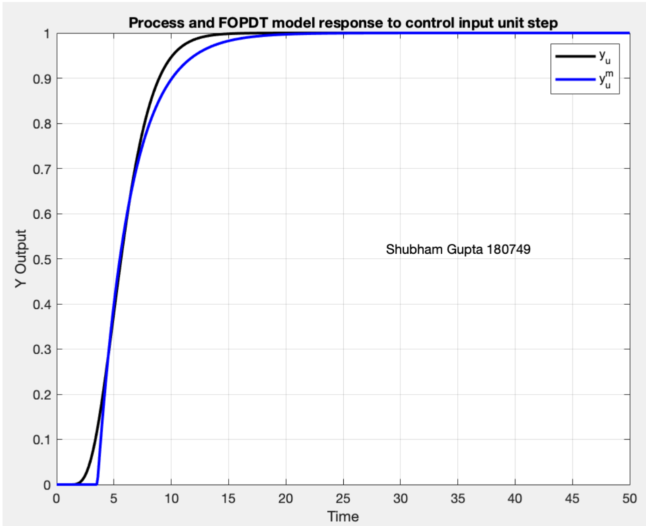
AIM:
- We need to fit first-order-plus-dead-time models to obtain G_P^m and G_D^m. Also design a simple feedforward compensator for the nominal process using the fitted transfer function models.
- Next we need to use fmincon to best fit the lead-lag and dead time parameters so that ISTAE for a unit step disturbance is minimized. Also design a PID feedback controller to minimize ISTAE for the unit step disturbance.
- Compare the nominally 'best' and 'simple' feedforward, 'best' feedback and feedforward-feedback controller performance for a unit step disturbance change.
- Find the percentage flow increase and decrease around the nominal for which the nominally tuned feedback controller remains stable. For smaller percentage flow change we need to comment on the deterioration in the tightness of the feedforward-feedback control compared to that using pure feedback control.

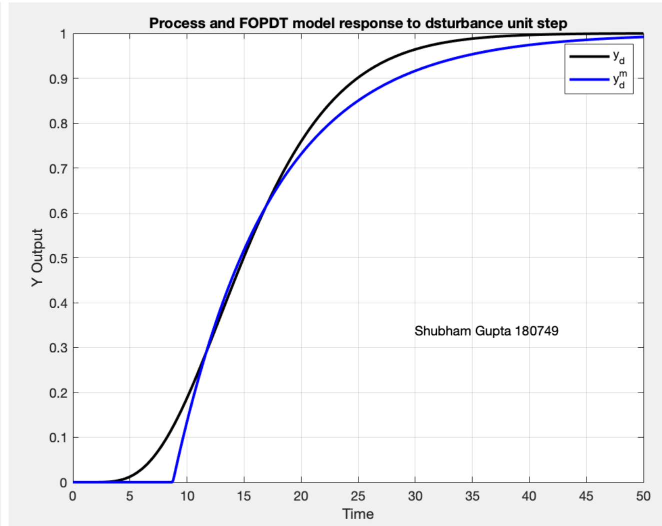
For simple feedforward, we can find the values of $\tau_{numerator}$, $\tau_{denominator,}$ and θ by looking at $T_{28.3\%}$ and $T_{63.2\%}$.

By using inverse transform for G_P^m and G_D^m. We get the following functions in time domain.
Inv(G_P^m) = [1 - t*exp(-t) - 0.5*t^2*exp(-t) - 0.16*t^3*exp(-t) - 0.04*t^4*exp(-t) - exp(-t)]
Inv(G_D^m) = [1 - 0.33*t*exp(-0.33*t) - 0.055*t^2*exp(-0.33*t) - 0.006*t^3*exp(-0.33*t) - 0.0005*t^4*exp(-0.33*t) - exp(-0.33*t)]

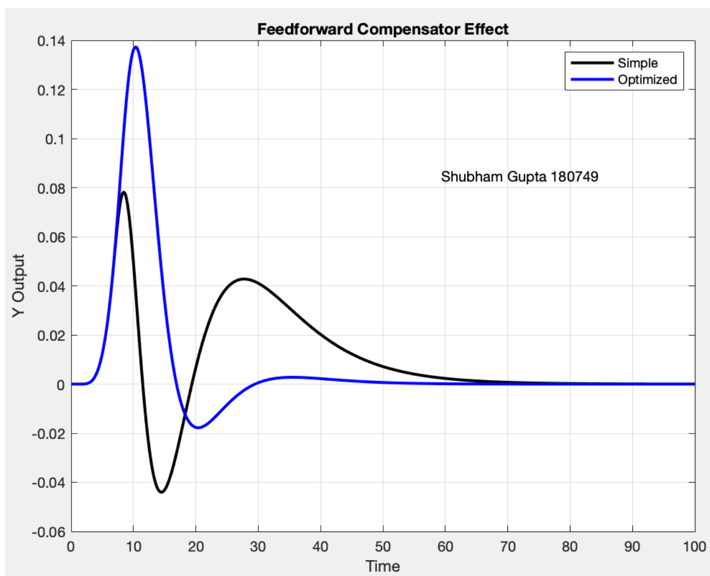
We can compute gain and time constant by using:
gain(**θ**) = $0.5(3T_{28.3\%} - T_{63.2\%})$
time constant(**τ**) = $1.5(T_{63.2\%} - T_{28.3\%})$

For control input: ThetaP = 2.605, TP = 2.829.
For disturbance input: ThetaD = 7.808, TD = 8.563.

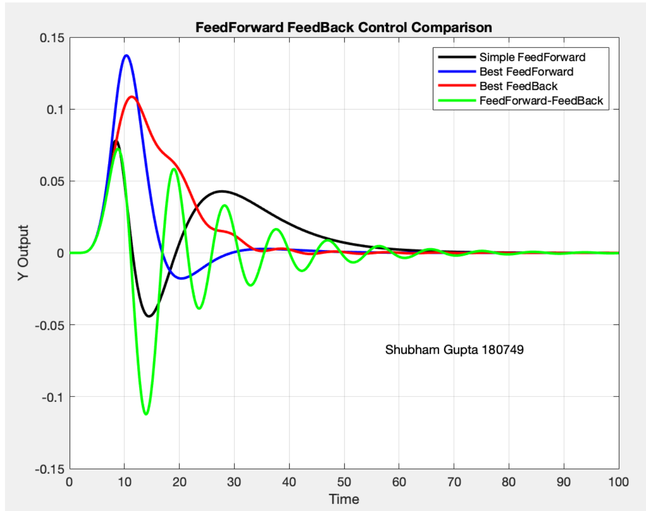




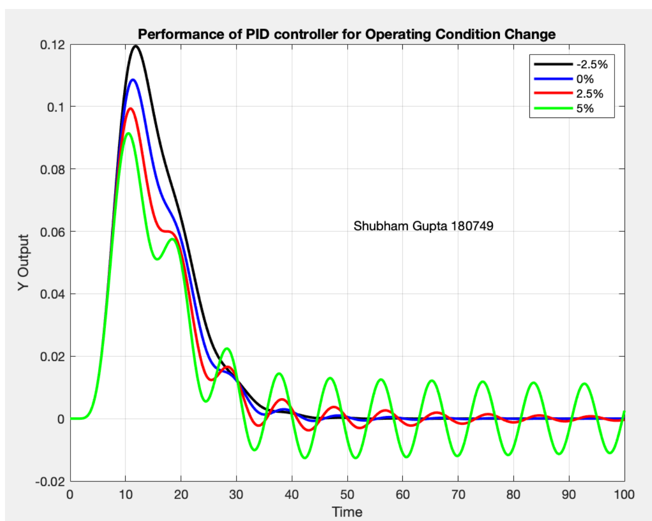
Later we need to minimse ISTAE to determine the values of τ_P, τ_D, and θ, using FMINCON.
Analytical Solution: $\tau_P = 8.56$, $\tau_D = 2.83$, $\theta = 5.2$.
Optimized Solution: $\tau_P = 5.51$, $\tau_D = 0.14$, $\theta = 5.44$.



Now we find the best FeedBack-PID parameters tuned for the model, using FMINCON.
Analytical Simple FeedForward Solution: $\tau_P = 8.56$, $\tau_D = 2.83$, $\theta = 5.2$.
FMINCON Best FeedForward Solution: $\tau_P = 5.51$, $\tau_D = 0.14$, $\theta = 5.44$.
FMINCON Best FeedBack-PID Solution: $K_c = 1.19$, $\tau_I = 1.72$, $\tau_D = 1.46$.
FMINCON combined FeedForward & FeedBack-PID Solution: $K_c = 1.19$, $\tau_I = 1.72$, $\tau_D = 1.46$, TP = 5.51, TD = 0.14, $\theta = 5.44$.

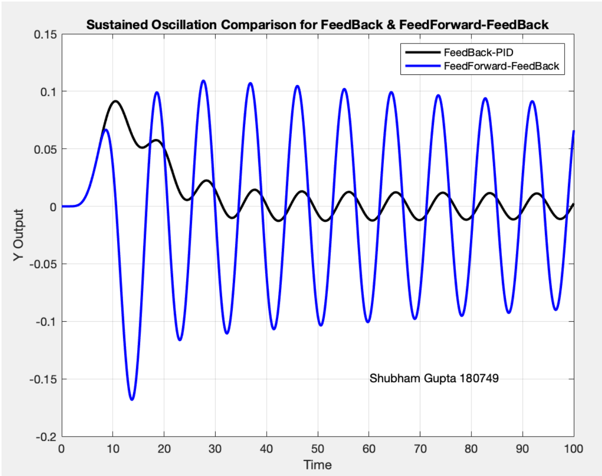


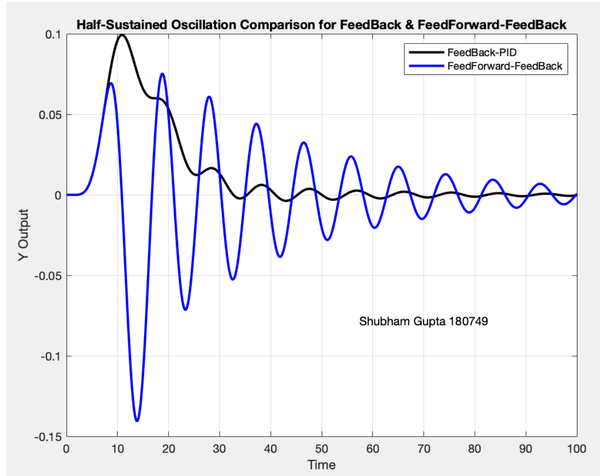
Now we find the percentage flow increase and decrease around the nominal for which the nominally tuned feedback controller remains stable.



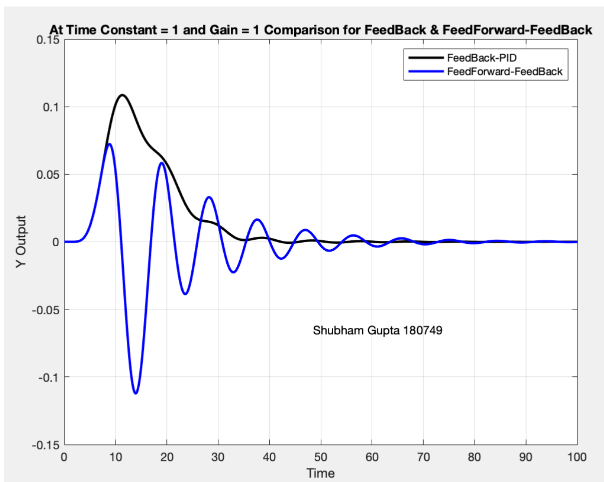
PID controller shows sustained oscillations at around 5%.

FeedBack-PID and FeedForward-FeedBack comparisons at full and half sustained oscillations.





At time constant = 1, and gain = 1, comparison for FeedBack-PID and FeedForward-FeedBack



CONCLUSION:

- On comparing all the tasks done, we see that best FeedForward gives best results which is followed by best FeedBack-PID.
- Parameters observed for the FeedForward using FMINCON are better aas they converge faster.
- FeedForward-FeedBaack has a lot of oscillation and takes a lot of time to complete, therefore it might not be desirable.
- PID controller shows sustained oscillations at around 5%.
- For best FeedBack and FeedForward-FeedBack, it is observed that the tightness of FeedForward-FeedBack deteriorates faster than FeedBack for percentage flow change of less than 2.5% .