Python For Chemical Engineering

Assignment 3:

Name: Arnav Shendurnikar

Roll No: 200929

Aim: To simulate the variation of temperature of fluid flowing in a cylindrical pipe having heat flux along the surface with time and space

Given:

Length of the pipe=50m

Radius of the pipe= 0.1 m

Number of nodes used= 100

Mass flow rate of the fluid= 3 kg/s

Heat capacity of water=4180 J/kgK

Density of water=1000kg/m3

Pi=3.14159

Pipe inlet temperature= Ti=400 K

Fluid initial temperature=T0=300K

Total simulation time=t_final=700 s

Time step=dt=1s

Total heat flux= q_flux=100000 W/m^2

dx=L/n

Calculations:

By using energy balance on the pipe,

$$q_{flux}.2\pi r \triangle x + mC_p\big(T(i-1) - T(i)\big) = \rho C_p \pi r^2 \triangle x \frac{dT(i)}{dt}$$

$$\frac{dT(i)}{dt} = \frac{q\_flux.2\pi r \triangle x + mC_p(T(i-1) - T(i))}{\rho C_p \pi r^2 \triangle x}$$

Under steady state,

$$\frac{dT(i)}{dt} = 0$$

Hence,

$$q_{flux}.2\pi r \triangle x + mC_p\big(T(i-1) - T(i)\big) = 0$$

$$q_{flux}.2\pi r.dx + mC_p(-dT) = 0$$

Hence by integrating,

$$T = q_{flux}.2\pi r.x/mC_p + C$$

By using boundary condition,

At x=0, T=Ti

$$C = T_i$$

Hence,

Steady state temperature variation,

$$T(x) = T_i + \frac{q\_flux.2\pi r}{mC_p}x$$

Algorithm:

1) Initialize the temperature, time and x matrix as 2d,1d and 1d array
2) Calculate the Tss (steady state temperature variation) using the following equation,

$$T(x) = T_i + \frac{q\_flux.2\pi r}{mC_p}x$$

3) For i varies from 1 to t_final:
   a. Calculate dTdt for all values of x using the following equation,

$$\frac{dT(i)}{dt} = \frac{q\_flux.2\pi r \triangle x + mC_p(T(i-1) - T(i))}{\rho C_p \pi r^2 \triangle x}$$

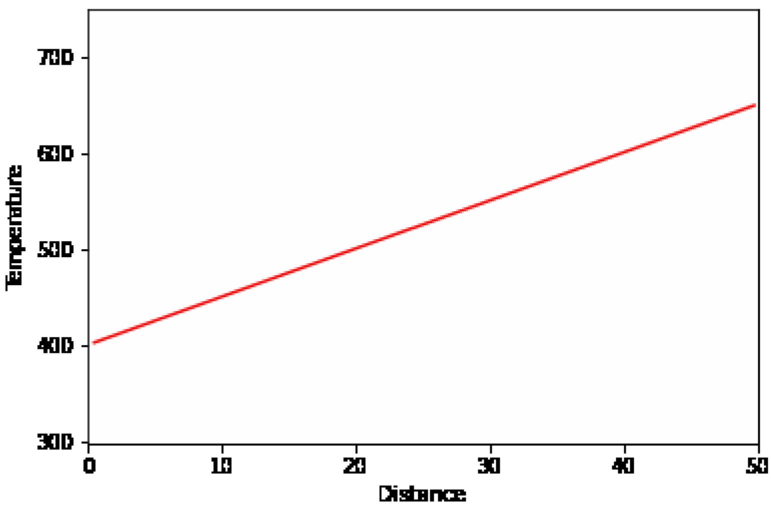
b. Calculate T using the following equation,

$$T(i)_k = T(i)_{k-1} + \frac{dT(i)}{dt}_k . \triangle t$$

c. Store the values in T_i matrix

4) Plot the variation of T_i with distance of pipe in which fluid has flown
5) Plot the variation of Tss with time in the same plot to compare the variation of T-i with Tss
6) Simulate the plots with time and store the simulation in form of 'gif'

Observations:



As the time progresses, the instantaneous temperature profiles varies and lines with the steady state profile. Another important observation is that the temperature of the pipe begins to rise even before the fluid has reached that part.