Python For Chemical Engineering

Assignment 4:

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Aim: To simulate the variation of temperature for concentric cylinder double pipe heat exchanger

Given:

Length of the pipe=L=60 m

Inner radius=r1= 0.1 m

Outer radius=r2=0.15 m

Number of nodes used= n=100

For fluid 1: Water

Mass flow rate of the fluid=m1= 3 kg/s

Heat capacity of water=Cp1=4180 J/kgK

Density of water=rho1=1000kg/m3

For fluid 2: Water

Mass flow rate of the fluid=m2= 3 kg/s

Heat capacity of water=Cp2=4180 J/kgK

Density of water=rho2=1000kg/m3

Initial temperature of fluid throughout pipe=T0=300K

Inlet temperature of fluid 1=T1i=400K

Inlet temperature of fluid 2=T2i=800K

Overall heat transfer coefficient=U=340 W/m^2

Total simulation time=t_final=700 s

Time step=dt=1s

dx=L/n

Calculations:

$$A_{c1} = \pi {r_1}^2$$

$$A_{c2} = \pi({r_2}^2 - {r_1}^2)$$

By using energy balance on the inner pipe,

In – Out + Generation = Accumulation

$$U.2\pi r_1 \triangle x\big(T_2(i) - T_1(i)\big) + m_1 C_{p1}\big(T_1(i-1) - T_1(i)\big) = \rho_1 C_{p1} A_{c1} \triangle x \frac{dT_1(i)}{dt}$$

$$\frac{dT_1(i)}{dt} = \frac{U.2\pi r_1 \triangle x\big(T_2(i) - T_1(i)\big) + m_1 C_{p1}\big(T_1(i-1) - T_1(i)\big)}{\rho_1 C_{p1} A_{c1} \triangle x}$$

Similarly for the outer pipe,

In – Out + Generation = Accumulation

$$U.2\pi r_1 \triangle x\big(T_1(i) - T_2(i)\big) + m_2 C_{p2}\big(T_2(i-1) - T_2(i)\big) = \rho_2 C_{p2} A_{c2} \triangle x \frac{dT_2(i)}{dt}$$

$$\frac{dT_2(i)}{dt} = \frac{U.2\pi r_1 \triangle x\big(T_1(i) - T_2(i)\big) + m_2 C_{p2}\big(T_2(i-1) - T_2(i)\big)}{\rho_2 C_{p2} A_{c2} \triangle x}$$

Algorithm:

1) Initialize the temperature, time and x matrix as 2d,1d and 1d array
2) For i varies from 1 to t_final:
    a. Calculate dTdt1 and dTdt2 for all values of x using the following equation,

$$\frac{dT_1(i)}{dt} = \frac{U.2\pi r_1 \triangle x\big(T_2(i) - T_1(i)\big) + m_1 C_{p1}\big(T_1(i-1) - T_1(i)\big)}{\rho_1 C_{p1} A_{c1} \triangle x}$$

$$\frac{dT_2(i)}{dt} = \frac{U.2\pi r_1 \triangle x\big(T_1(i) - T_2(i)\big) + m_2 C_{p2}\big(T_2(i-1) - T_2(i)\big)}{\rho_2 C_{p2} A_{c2} \triangle x}$$

b. Calculate T_1 and T_2 using the following equation,

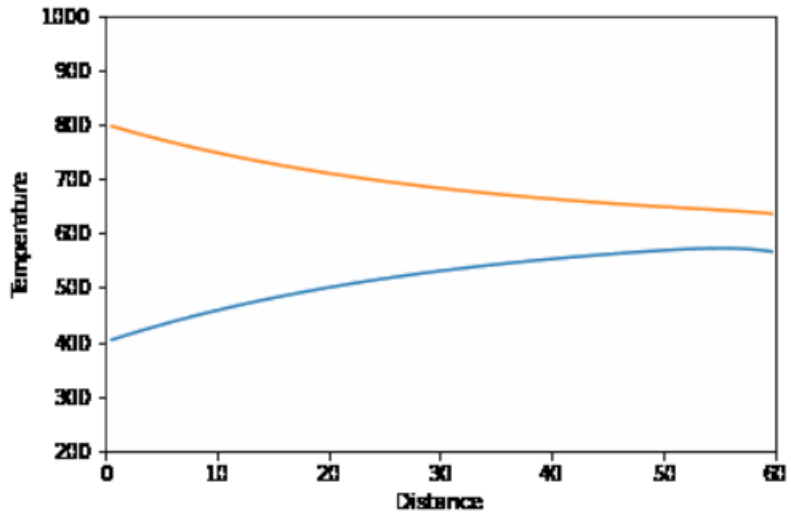
$$T_1(i)_k = T_1(i)_{k-1} + \frac{dT_1(i)}{dt}_k .\triangle t$$

$$T_2(i)_k = T_2(i)_{k-1} + \frac{dT_2(i)}{dt}_k .\triangle t$$

c. Store the values in T_1 and T_2 matrix that varies with time

3) Plot the variation of T_1 and T_2 with distance of pipe in which fluid has flown on the same graph to compare the temperature variations in both the parts of the pipe.
4) Simulate the plots with time and store the simulation in form of 'gif'

Observations:



The yellow graph shows the temperature of the outer pipe and the blue graph shows the temperature of the inner pipe. It can be observed that the temperature of both the parts is converging with time.