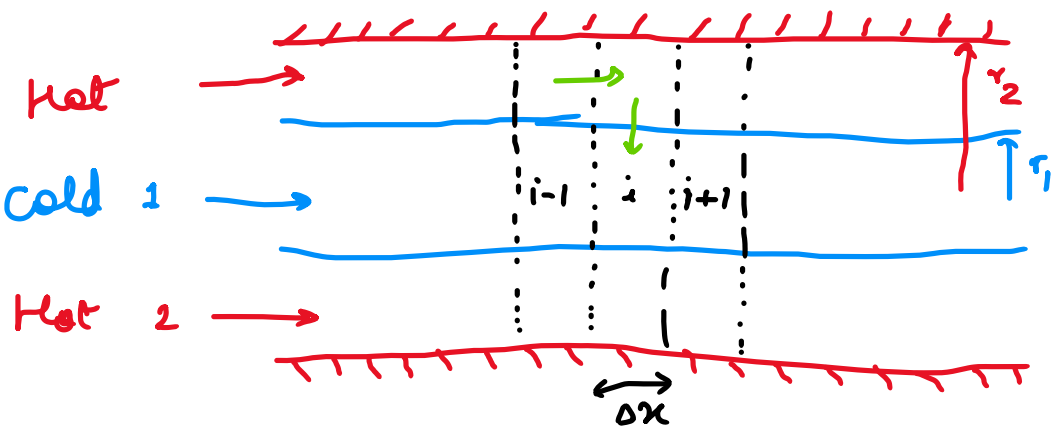
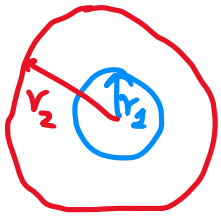
Co-current flow



Side view

Concentric cylinders



Front view

Energy balance :

$A_{c_1} = \pi r_1^2$, $A_{c_2} = \pi(r_2^2 - r_1^2)$

Accumulation = In - Out + Generation

For inner cylinder :

$$\rho_1 C_{p,1} A_{c1} \Delta x \frac{dT_1}{dt} = \dot{m}_1 C_{p1}\left(T(i-1) - T(i)\right) + U.2\pi r_1 \Delta x \left(T_2(i) - T_1(i)\right)$$

$$\Rightarrow \boxed{\frac{dT_1}{dt} = \frac{\dot{m}_1 C_{p1}\left(T_1(i-1) - T_1(i)\right) + U.2\pi r_1 \Delta x\left(T_2(i) - T_1(i)\right)}{\rho_1 C_{p,1} A_{c1} \Delta x}} \quad -(1)$$

For outer cylinder :

$$\rho_2 C_{p,2} A_{c2} \Delta x \frac{dT_2}{dt} = \dot{m}_2 C_{p2}\left(T_2(i-1) - T_2(i)\right) - U.2\pi r_1 \Delta x \left(T_2(i) - T_1(i)\right)$$

$$\Rightarrow \frac{dT_2}{dt} = \frac{\dot{m}_2 C_{p2} \left(T_2(i-1) - T_2(i)\right) - U \cdot 2\pi r_1 \cdot \Delta x \left(T_2(i) - T_1(i)\right)}{\rho_2 C_{p2} A_{c2} \Delta x} \quad -(2)$$

Assignment Question :

Solve, and obtain the transient response of Temperature with time for the concentric cylinder double pipe heat exchanger, as shown above.

Details:

1) Length of pipe = L = 60 m
2) Inner radius = r1 = 0.1 m
3) Outer radius = r2 = 0.15 m
4) Number of internal points = n = 100 (Can increase this for better accuracy)

5) For fluid 1 (Water here):
   1) m1 = Mass flow rate = 3 kg/s
   2) Cp1 = Heat capacity of fluid (water) = 4180 J/kg.K
   3) rho1 = Density of fluid (water) = 1000 kg/m^3

6) For fluid 2 (Water here again):
    1) m2 = Mass flow rate = 5 kg/s
    2) Cp2 = Heat capacity of fluid (water) = 4180 J/kg.K
    3) rho2 = Density of fluid (water) = 1000 kg/m^3

7) Initial temperature of fluid throughout the pipe = T0 = 300K
8) Inlet temperature of fluid 1 = T1i = 400 K
9) Inlet temperature of fluid 2 = T2i = 800 K
10) Overall heat transfer coefficient = U = 340 W/m^2

Simulate for t_final = 1000 seconds, with a time step (Δt) of 1 sec for each step.

For each time step, get the temperature profile (T1 and T2 for the whole pipe) and plot them in a single figure. Clear the figure, and update that plot with the next figure (next time step).