Assignment-1

Find the variation of the Inner wall temperature(T_i) & Outer wall temperature(T_o) of the duct with the change of air velocity, if it is known that heat flux provided by the heater is constant q_o'' =5000W/m^2. Assume other conditions of the problem are same.

Also find the Inner and Outer wall temperature at air velocity=15m/s.

Draw a comparative plot of To with velocity in a single graph for

these two situations (1. Ti=constant=85 degree centigrade 2. q_o''=constant=5000W/m^2); Use different color of these two plots

Solution:

From equivalent thermal circuit:

For case-1: Heat flux=constant

$$q_0'' = \frac{T_o - T_i}{\frac{t}{k}} = \frac{T_i - T_\infty}{\frac{1}{h}}$$

$$T_i = T_\infty + \frac{q_0''}{h}$$

$$T_o = T_i + q_0''\frac{t}{k}$$

Now convective heat transfer coefficient (h) can be defined using correlation $h = CV^n$, where $C = 10, n = 0.8$

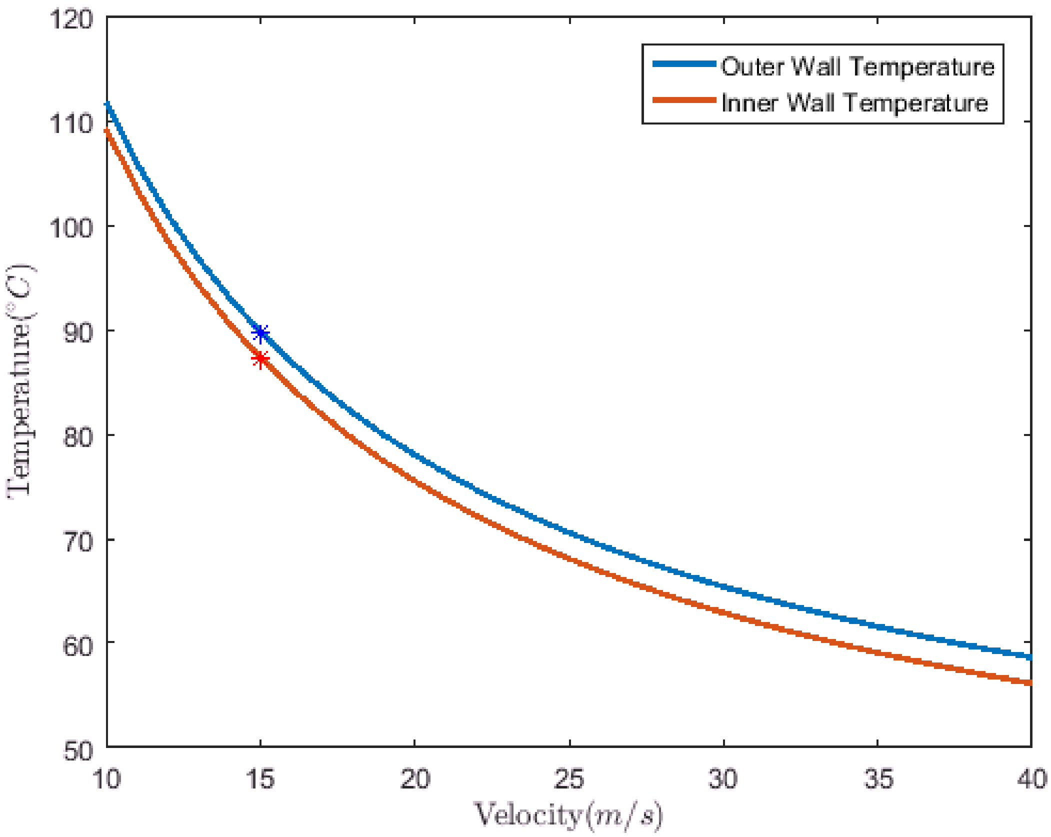
```
% Given conditions
T_inf=30; % Temperature of the air in the duct in centigrade
k=20; % Thermal conductivity of duct wall in W/m.K
t=0.01; % Thickness of the duct wall 10mm=0.01m

% h calculation from velocity
v=[1:40]'; % velocity as column vector
C=10;
n=0.8;
h=C*v.^n; % convective heat transfer coefficient

%Case-1: Heat flux q''=5000 SI unit
q_flux=5000; % SI unit

% Inner wall temperature of the duct (Ti) calculation
T_i=T_inf+q_flux./h;
% Outer wall temperature of the duct (To) calculation
T_o=T_i+q_flux*t/k;
%Outer & Inner wall Temperature at velocity 15m/s
v_target=15; % to find out quantities at given v=15m/s
disp(['Outer wall temperature at ',num2str(v_target),' m/s is ',num2str(T_o(v_target)),' degre
```

```
Outer wall temperature at 15 m/s is 89.7924 degree centigrade
```

```
disp(['Inner wall temperature at ',num2str(v_target),' m/s is ',num2str(T_i(v_target)),' degre
```

```
Inner wall temperature at 15 m/s is 87.2924 degree centigrade
```

```
% Variation of To & Ti for case-1 constant heat flux 5000 SI unit
%subplot(2,2,1);
figure(1)
plot(v(10:40),T_o(10:40),v(10:40),T_i(10:40),'LineWidth',2);
xlabel('Velocity($m/s$)','Interpreter','latex');
ylabel('Temperature($^{\circ} C)$','Interpreter','latex');
legend('Outer Wall Temperature','Inner Wall Temperature');
hold on
 plot(v(v_target),T_o(v_target),'b*');plot(v(v_target),T_i(v_target),'r*');
 hold off;
```



For Case-2: Inner Wall temperature=constant

Now Heat flux variation can be evaluated by using Newton's law

$$q_o'' = h(T_i - T_\infty)$$

Now, Outside wall temperature T_o can be found out by using Fourier's law of heat conduction

$$q_o'' = -k\frac{(T_i - T_o)}{t}$$

$$\Rightarrow T_o = \frac{q_o'' t}{k} + T_i$$

```
T_i_2=85; %Constant Inner wall temperature for case-2
q_flux_2=(T_i_2-T_inf).*h;
% Outer wall temperature calculation
T_o_2=T_i_2+(t/k).*q_flux_2;

% Variation of To for case-1 & case-2
%subplot(2,2,2);
figure(2)
plot(v(10:40),T_o(10:40),v(10:40),T_o_2(10:40),'LineWidth',2);
xlabel('velocity($m/s)$','Interpreter','latex');
ylabel('Temperature($^{\circ} C)$','Interpreter','latex');
legend('To for q"=constant','To for Ti=constant');
```