MM218 Programming Assignment

Group: 15
Problem: 3

Results from Proposal:

For Surface node:

$T_o^p = (1+2F_0)T_o^{p+1} - 2F_0T_1^{p+1}$ (Insulated =>Convection term is 0)

For interior nodes:

$T_m^p = (1+2F_0)T_m^{p+1} - F_0(T_{m-1}^{p+1} + T_{m+1}^{p+1})$

In matrix form ,we have

$$\begin{bmatrix} 1+2F_0 & -2F_0 & 0 & 0 & 0 \\ -F_0 & 1+2F_0 & -F_0 & 0 & 0 \\ 0 & -F_0 & 1+2F_0 & -F_0 & 0 \\ 0 & 0 & -F_0 & 1+2F_0 & -F_0 \\ 0 & 0 & 0 & -F_0 & 1+2F_0 \end{bmatrix} \begin{bmatrix} T_0^{p+1} \\ T_1^{p+1} \\ T_2^{p+1} \\ T_3^{p+1} \\ T_4^{p+1} \end{bmatrix} = \begin{bmatrix} T_0^p \\ T_1^p \\ T_2^p \\ T_3^p \\ T_4^p \end{bmatrix}$$

(a) Stopping Criteria :

$$T_i - T_{s,l} = 0.5(T_i - T_{s,r})$$
$$\Rightarrow T_{s,l} = 0.5(T_i + T_{s,r})$$

For arbitrary values of Ti (=100) and Ts,r (=50) , Ts,l = 75

Result after iteration:

Time taken for the temperature at the left face Ts,l to achieve 50% of its possible temperature reduction = 64 s

Analytical solution = 64.14s

(b) Stopping Criteria :

$$T_i - T_{s,l} = 0.2(T_i - T_{s,r})$$
$$\Rightarrow T_{s,l} = 0.8T_i + 0.2T_{s,r}$$

For arbitrary values of Ti (=100) and Ts,r (=50) ,Ts,l = 90

Result after iteration:

Time taken for the temperature at the left face to recover to a 20% temperature reduction = 92s

Code:

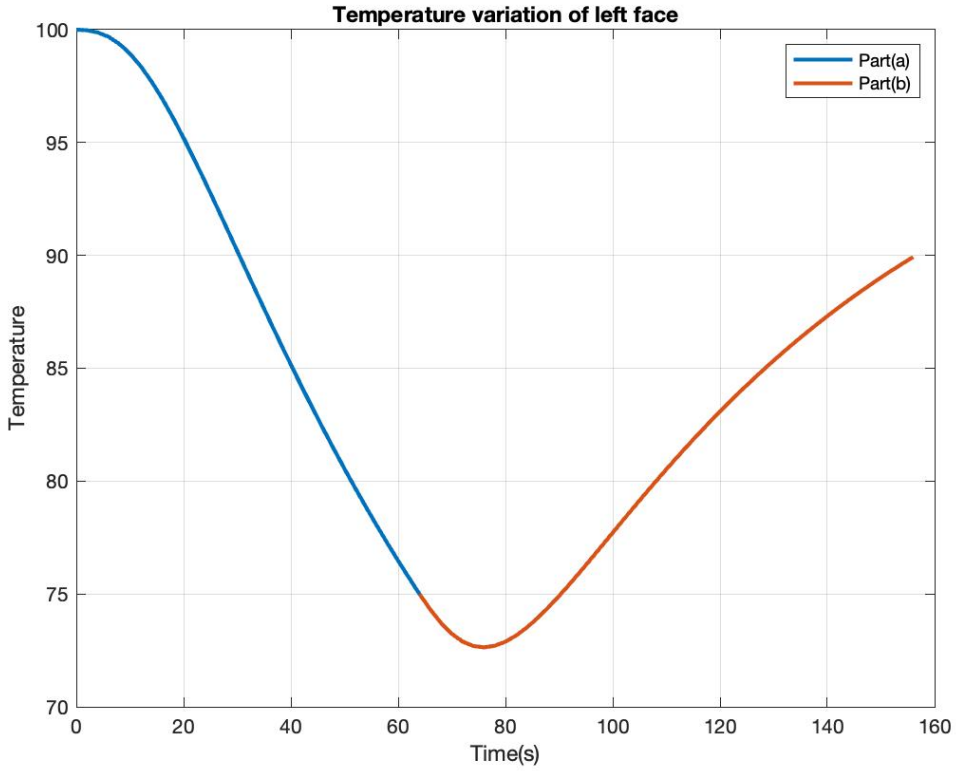
MM218_project.m

```
clear all;
clc;

%Constants
a = 6e-7;%m^2/s
dt = 2;%s
dx = 2e-3;%m
F = a*dt/dx^2;
Ti = 100;%Arbitrary Value
T5 = 50;%Arbitrary Value,Same as Ts,r
Tf = (Ti+T5)/2;%Target Temperature of node 0
tolerance = 0.1;

X = [Ti;Ti;Ti;Ti;Ti];%Initial temperature of nodes T[m,0], m = 0-4

for i = 1:100
    TDistribution_a(:,i) = X; %Temperature distribution of nodes T[m,0], m = 0-4
    A = [
        1+2*F -2*F 0 0 0;
        -F 1+2*F -F 0 0;
        0 -F 1+2*F -F 0;
        0 0 -F 1+2*F -F;
        0 0 0 -F 1+2*F;
        ];%Matrix obtained after substituting values in equations given in the proposal

    B = X +[0;0;0;0;F*T5];

    X = A \B;
    if abs(TDistribution_a(1,i)-Tf) <= tolerance
        break;
    end
end


T_50percent = (i-1)*dt;
fprintf('(a)Time taken for a temperature reduction of 50%% = %ds\n',T_50percent);

plot(0:dt:(i-1)*dt,TDistribution_a(1,:),LineWidth=2)
xlabel('Time(s)')
ylabel('Temperature')
title('Temperature variation of left face')
grid on;


Tf = 0.8*Ti+0.2*T5;
T5 = Ti;
X = TDistribution_a(:,i);

for i = 1:100
    TDistribution_b(:,i) = X;
    A = [
        1+2*F -2*F 0 0 0;
        -F 1+2*F -F 0 0;
        0 -F 1+2*F -F 0;
        0 0 -F 1+2*F -F;
        0 0 0 -F 1+2*F;
        ];

    B = X +[0;0;0;0;F*T5];

    X = A \B;
    if abs(TDistribution_b(1,i)-Tf) <= tolerance
        break;
    end
end

fprintf('(b)Further time taken to recover to initial 20%% reduction = %ds\n',(i-1)*dt);

hold on;
plot(0+T_50percent:dt:T_50percent+(i-1)*dt,TDistribution_b(1,:),LineWidth=2)
legend('Part(a)','Part(b)')
hold off;

print('MM218_project','-dpng')

```

Output:

```
Command Window
(a)Time taken for a temperature reduction of 50% = 64s
(b)Further time taken to recover to initial 20% reduction = 92s
>>
```

Temperature variation of the left face for the entire duration:



Analysis:

- Initially when temperature of the right face is suddenly reduced, the heat flow is from left to right which is depicted by the blue curve in the above plot.
- Later when temperature of the right face is suddenly increased,the left side temperature decreased to reach a minima (because the wall is of a finite thickness) and started increasing (Red curve).The heat flow is from right to left .

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