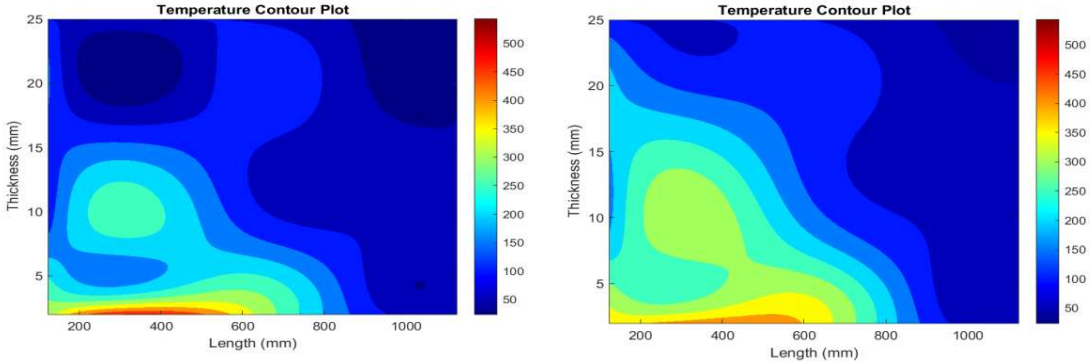
Appendix A

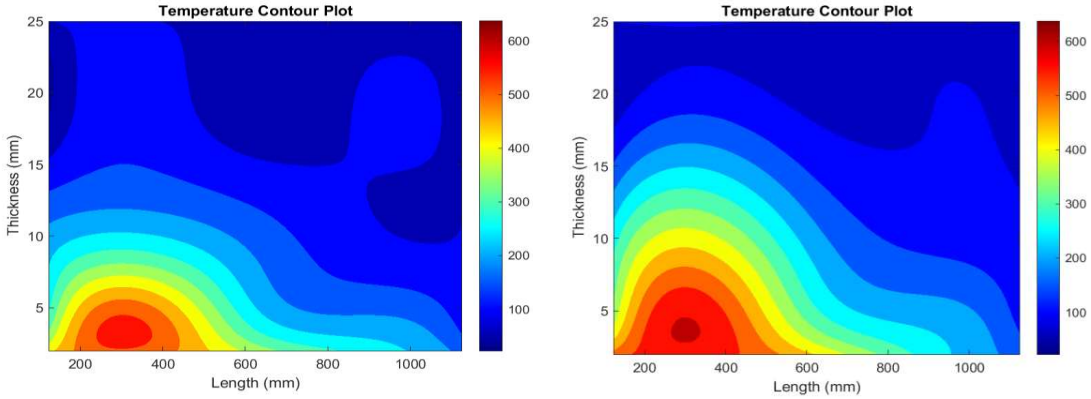
Thermal penetration into the thickness

The temperature penetrated and travelled into the thickness of the sample. The rate of this thermal penetration was dependent on the incident heat flux. Higher the heat flux value higher the penetration rate into the thickness. The contour plots for the temperature isotherms travelling into the thickness are presented below for all the tests.



t=30min t=35min

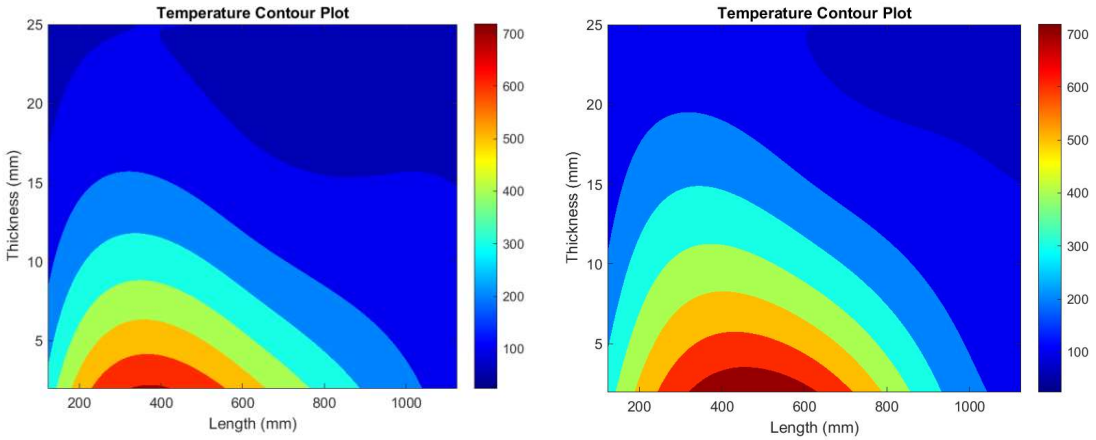
Figure A-1 Temperature penetration contour plots for Test 1



t=20min t=25min

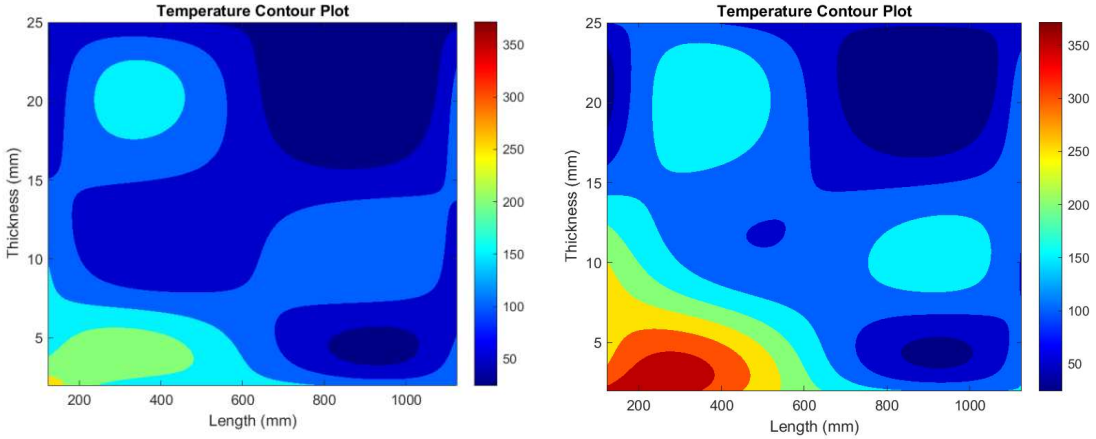
Figure A-2 Temperature penetration contour plots for Test 2

a



t=25min t=30min

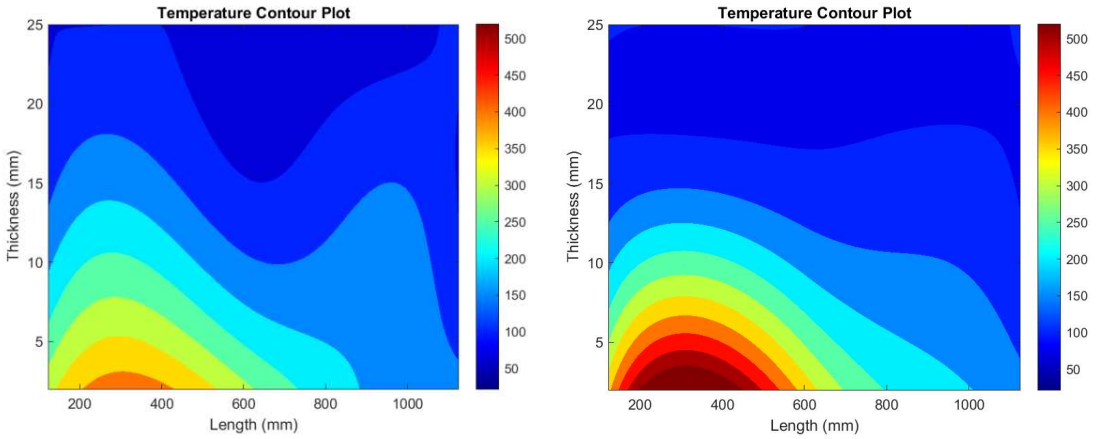
Figure A-3 Temperature penetration contour plots for Test 3



t=20min t=27min

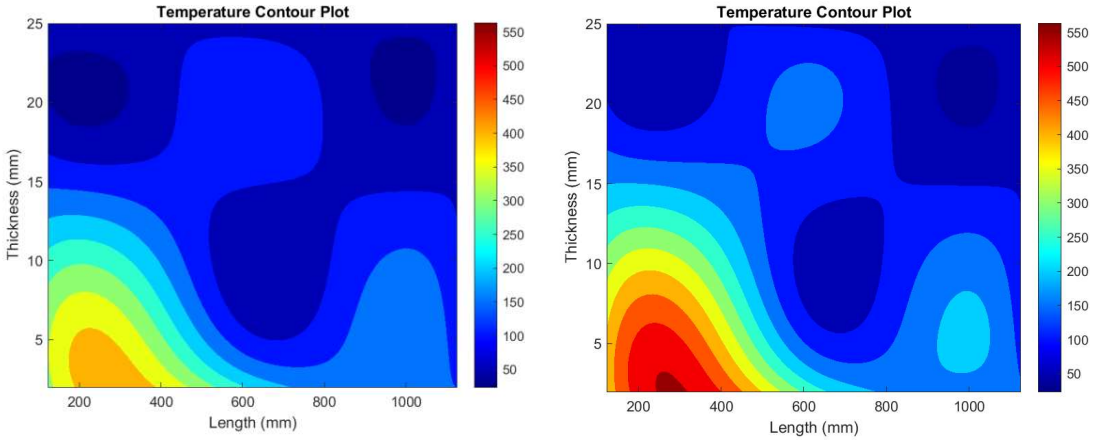
Figure A-4 Temperature penetration contour plots for Test 4

b



t=40min t=43min

Figure A-5 Temperature penetration contour plots for Test 5



t=40min t=43min

Figure A-6 Temperature penetration contour plots for Test 6

Appendix B

Temperature Time History Plots for Solid Phase TC

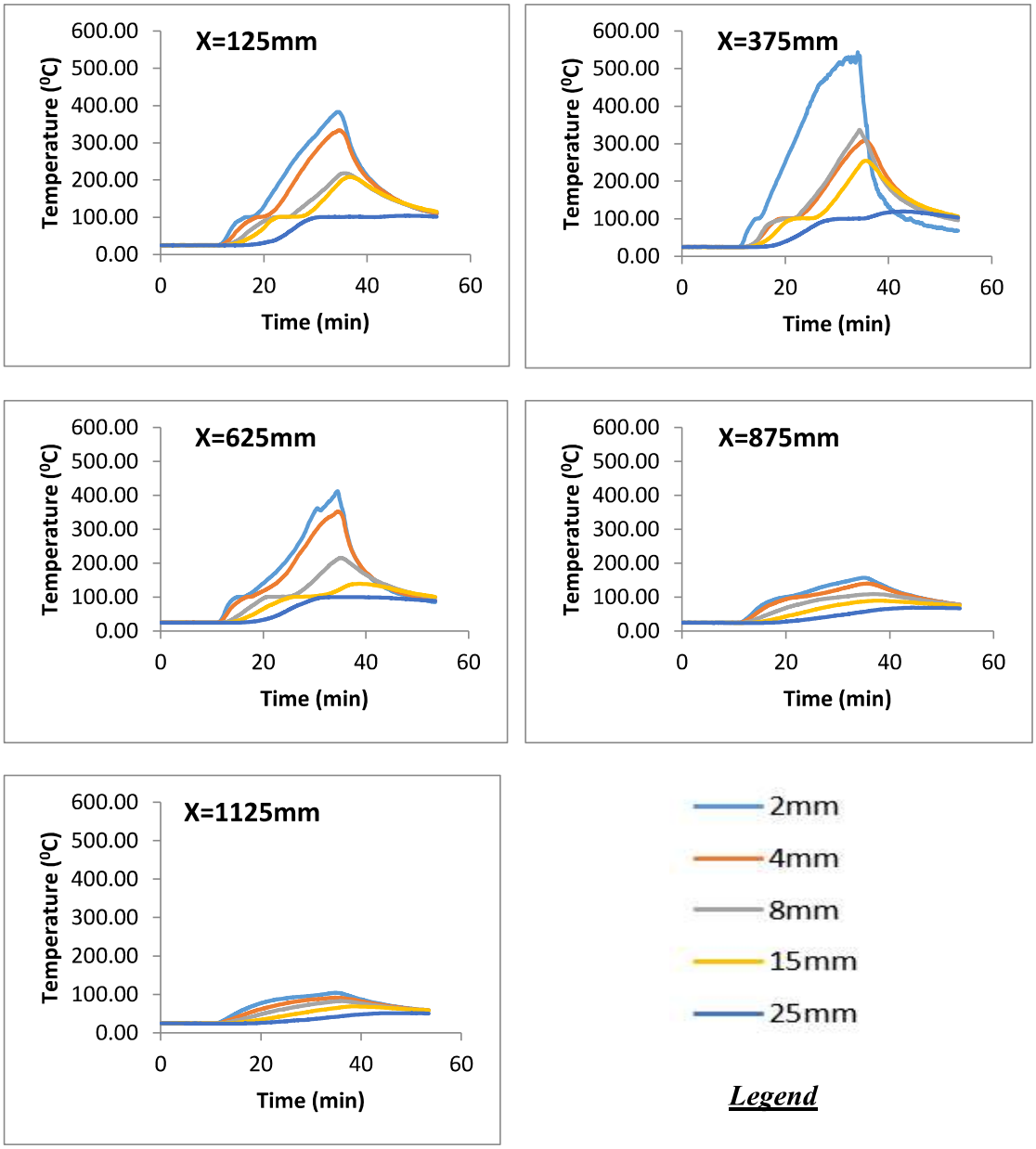


Figure B-1 Temperature histories through thickness for Test 1

d

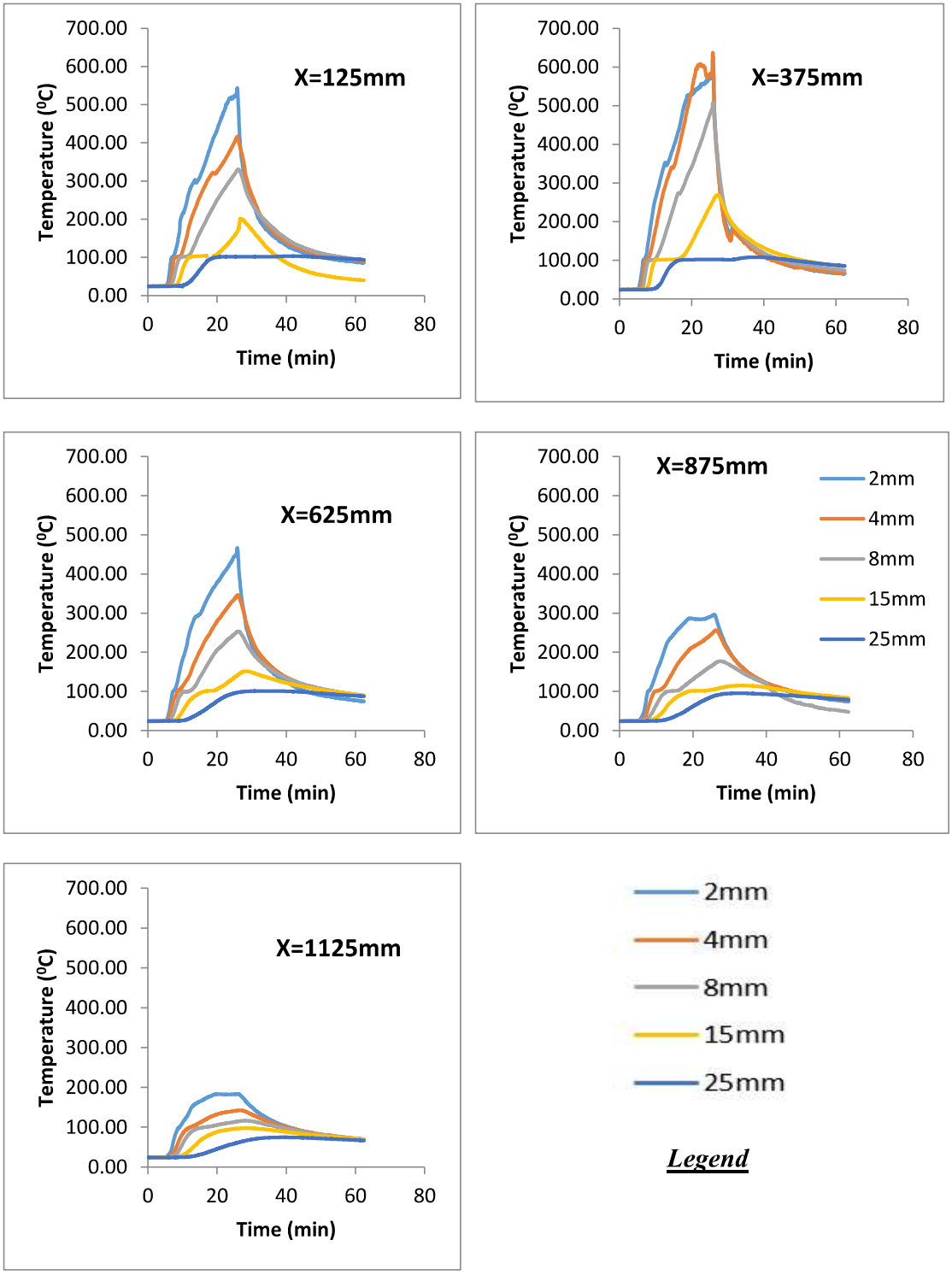


Figure B-2 Temperature histories through thickness for Test 2

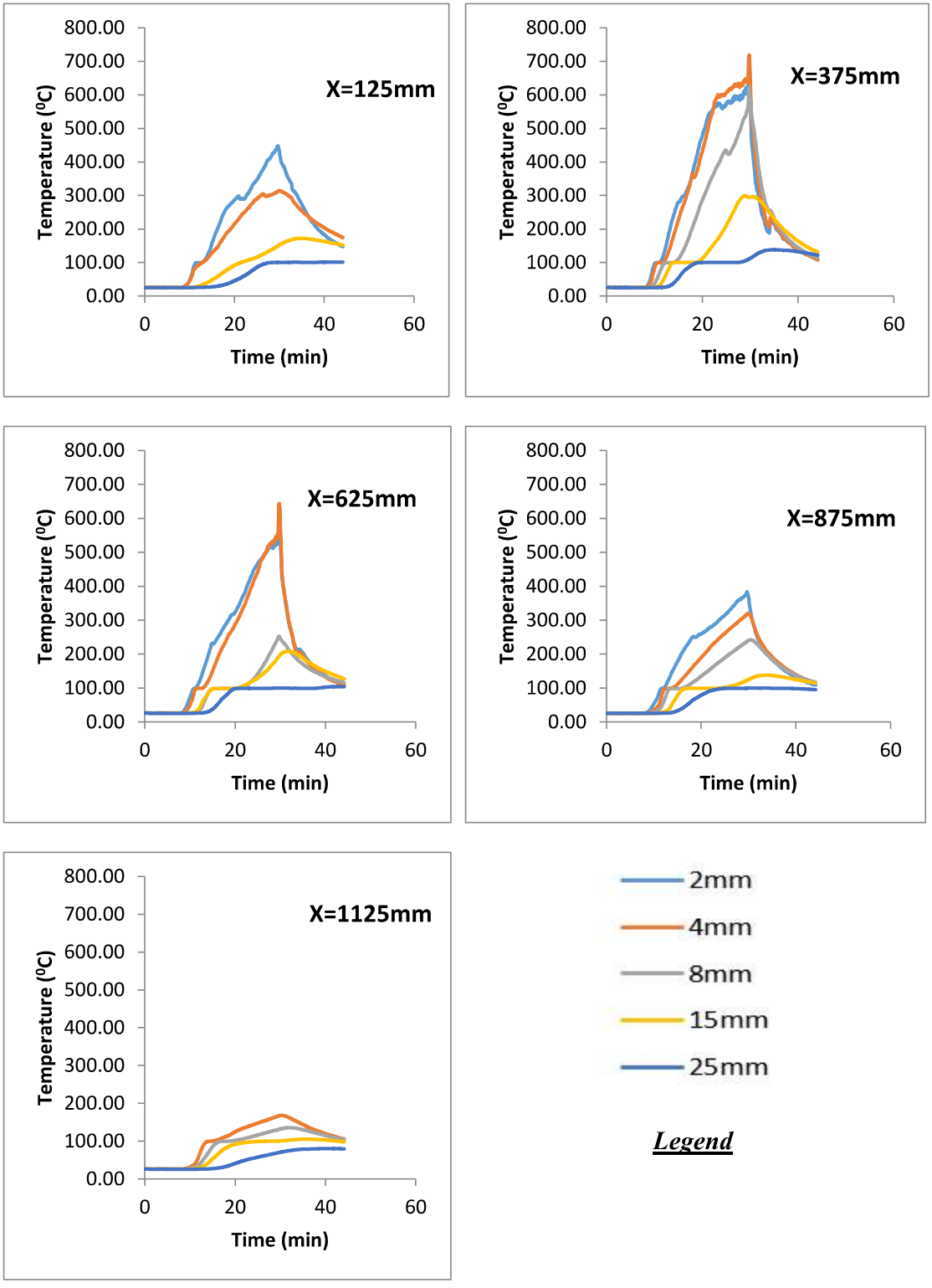


Figure B-3 Temperature histories through thickness for Test 3

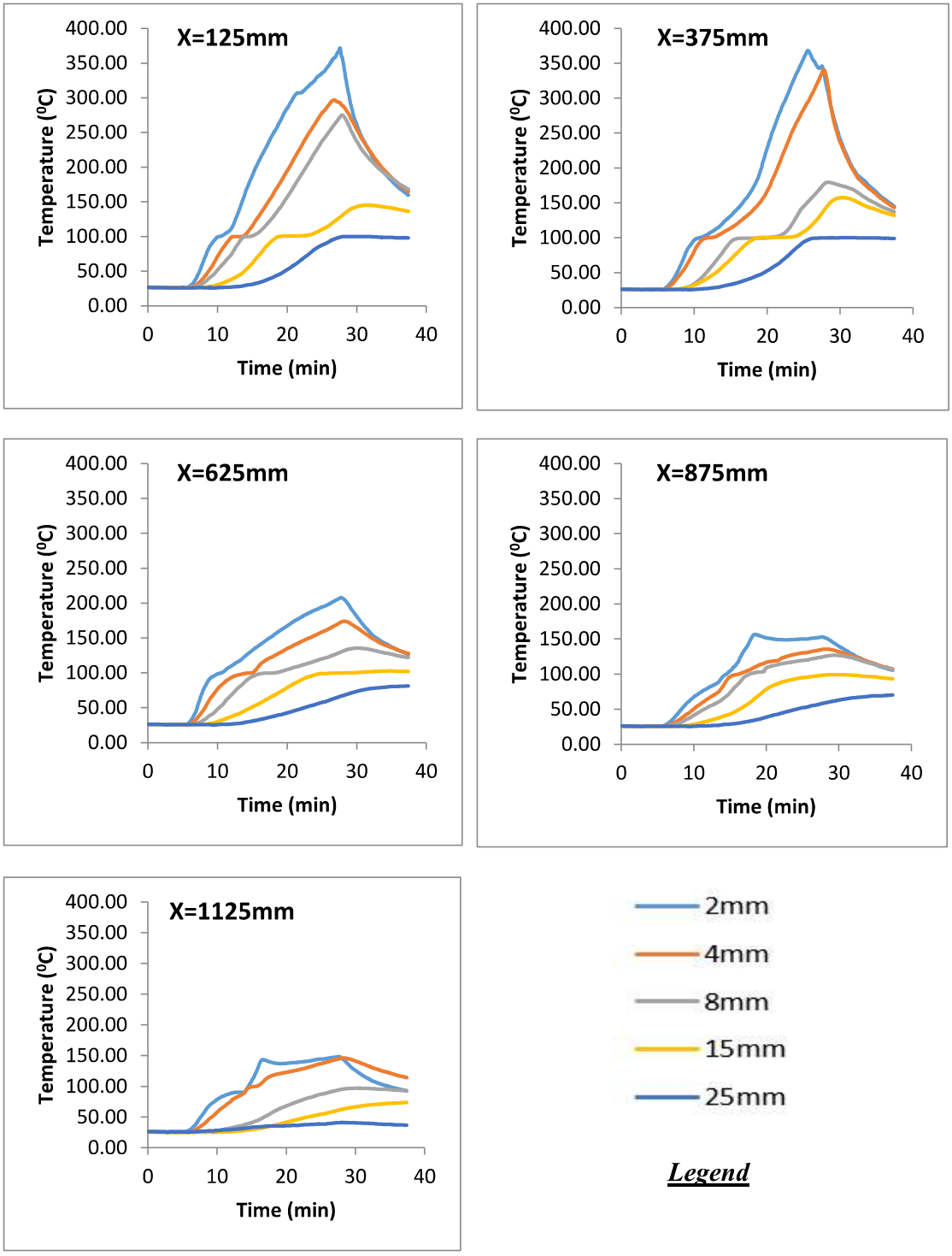


Figure B-4 Temperature histories through thickness for Test 4

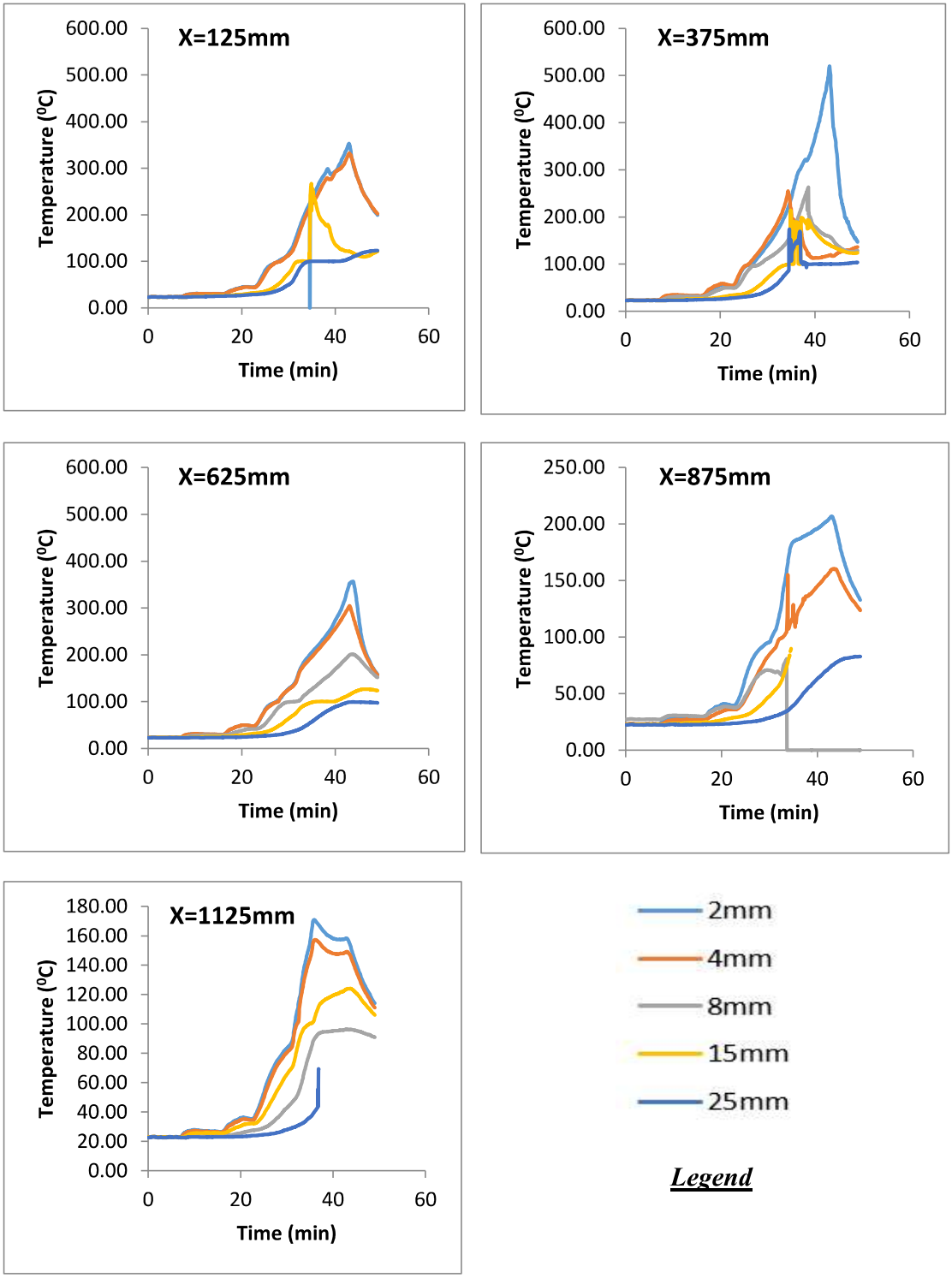


Figure B-5 Temperature histories through thickness for Test 5

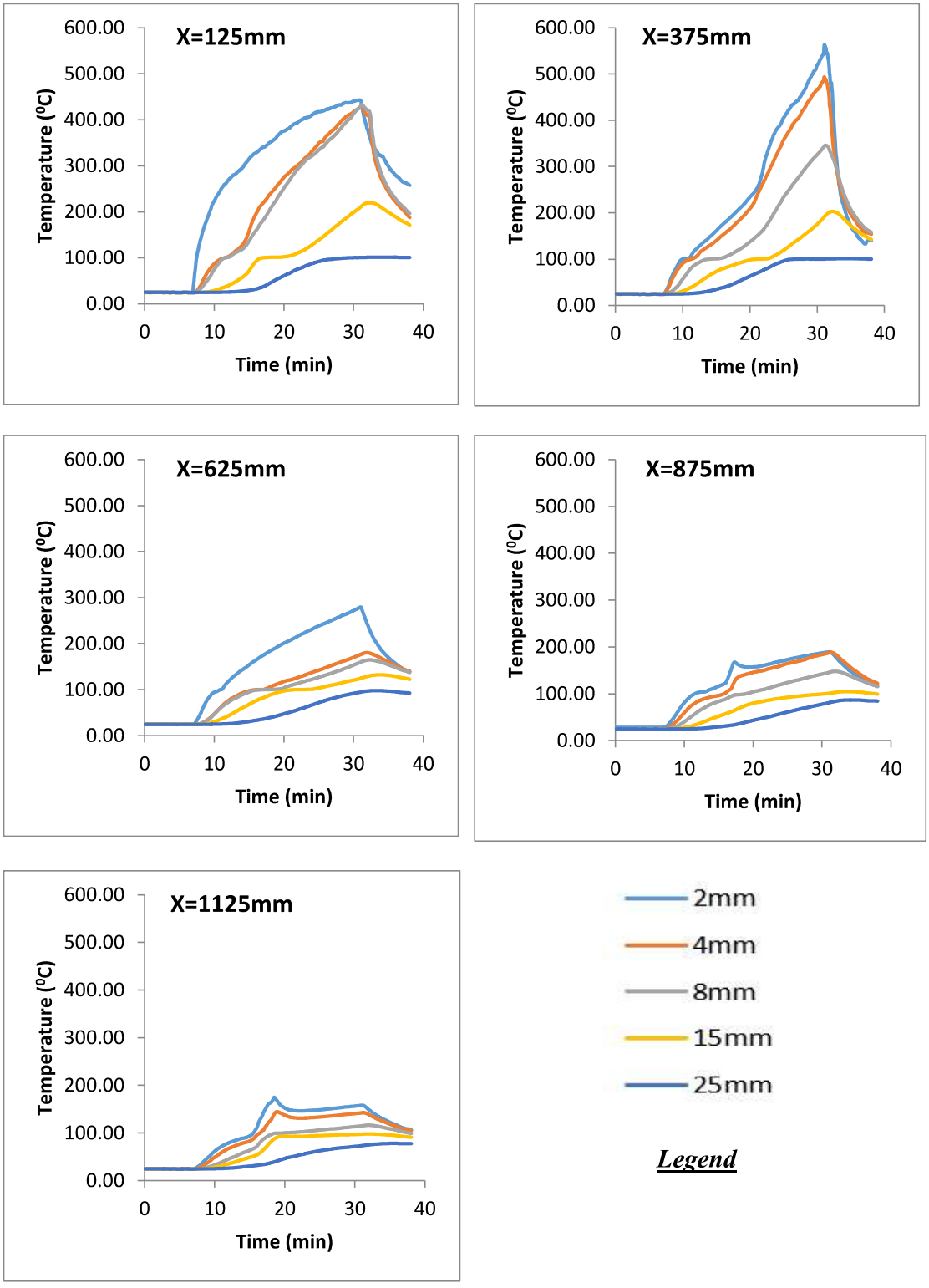


Figure B-6 Temperature histories through thickness for Test 6

Appendix C

Sample Drawing

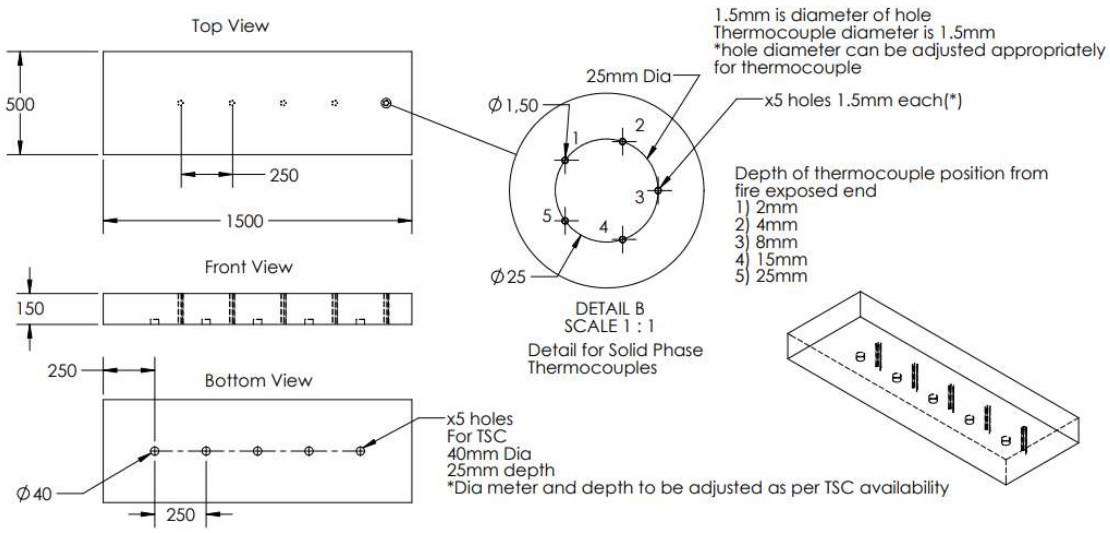


Figure C-1 Sample drawing/drilling template

Appendix D

MATLAB Scripts

Script for flame contours is presented below

```
clc
clear
% Load temperature data from Excel file
data = xlsread('flame spread calc2.xlsx');
x = data(:,1); % x-axis values
y = data(:,2); % y-axis values
T = data(:,3:end); % temperature values
N=size(T,2);
% Reshape temperature data to a 2D array for contour plot
n = length(unique(y));
m = length(unique(x));
a=unique(x);
b=unique(y);

for k=1:N
    my_field = strcat('Tmatrix_',num2str(k));
    variable.(my_field) = reshape(T(:,k), n, m);;
    %T_matrix0 = reshape(T(:,k), n, m);
    [X,Y] = meshgrid(a,b);
    BDmatrix=variable.(my_field);
    newpoints = 100;
    [xq,yq] = meshgrid(linspace(min(a),max(a),newpoints
),linspace(min(b),max(b),newpoints));
    BDmatrixq = interp2(X,Y,BDmatrix,xq,yq,'spline');
    %[c,h]=contourf(xq,yq,BDmatrixq);
    % Create contour plot
    f=figure;

    [c,h]=contourf(xq,yq,BDmatrixq,'edgecolor','none');
    caxis([0,1])
    c = gray(2);
    colormap(flipud(c));
    %colorbar;
    xlabel('Length (mm)');
    ylabel('Width (mm)');
    title('Flame Contour Plot');
    saveas(f, strcat('Test2_',num2str(k)),'png');
end
```

Script for extrapolation for surface temperature is presented below

```
clc
clear
% Load temperature data from Excel file
[num, txt, raw] = xlsread('surftemp.xlsx');
t = num(:,1); % Times in seconds
temp_2mm = num(:,2); % Temperatures at 2mm in degrees Celsius
temp_4mm = num(:,3); % Temperatures at 4mm in degrees Celsius
temp_8mm = num(:,4); % Temperatures at 8mm in degrees Celsius

% Interpolate temperature at x = 0 mm for each time value using quadratic
interpolation
y = [2 4 8];
temp = [temp_2mm temp_4mm temp_8mm];
yq = 0;

N=length(t);
for i=1:N
    tempq1(i) = interp1(y, temp(i,:), yq, 'spline', 'extrap');
    if tempq1(i)<max(temp(i,:))
        tempq1(i)=max(temp(i,:));
    end
end
tempq1=tempq1(:);

% Plot temperature at x = 0 mm as a function of time
% figure;
% plot(t, tempq1);
% hold on
% plot(t, temp);
% hold off
% xlabel('Time (s)');
% ylabel('Temperature (C)');
%title('Temperature at x = 0 mm vs Time');

temp_2mm = num(:,6); % Temperatures at 2mm in degrees Celsius
temp_4mm = num(:,7); % Temperatures at 4mm in degrees Celsius
temp_8mm = num(:,8); % Temperatures at 8mm in degrees Celsius

% Interpolate temperature at x = 0 mm for each time value using quadratic
interpolation
y = [2 4 8];
temp = [temp_2mm temp_4mm temp_8mm];
yq = 0;

N=length(t);
for i=1:N
    tempq2(i) = interp1(y, temp(i,:), yq, 'spline', 'extrap');
    if tempq2(i)<max(temp(i,:))
        tempq2(i)=max(temp(i,:));
    end
end
```

```
tempq2=tempq2(:);

% Plot temperature at x = 0 mm as a function of time
% figure;
% plot(t, tempq2);
% hold on
% plot(t, temp);
% hold off
% xlabel('Time (s)');
% ylabel('Temperature (C)');
%title('Temperature at x = 0 mm vs Time');

temp_2mm = num(:,10); % Temperatures at 2mm in degrees Celsius
temp_4mm = num(:,11); % Temperatures at 4mm in degrees Celsius
temp_8mm = num(:,12); % Temperatures at 8mm in degrees Celsius

% Interpolate temperature at x = 0 mm for each time value using quadratic
interpolation
y = [2 4 8];
temp = [temp_2mm temp_4mm temp_8mm];
yq = 0;

N=length(t);
for i=1:N
    tempq3(i) = interp1(y, temp(i,:), yq, 'spline', 'extrap');
    if tempq3(i)<max(temp(i,:))
        tempq3(i)=max(temp(i,:));
    end
end
tempq3=tempq3(:);

% Plot temperature at x = 0 mm as a function of time
% figure;
% plot(t, tempq3);
% hold on
% plot(t, temp);
% hold off
% xlabel('Time (s)');
% ylabel('Temperature (C)');
%title('Temperature at x = 0 mm vs Time');

temp_2mm = num(:,14); % Temperatures at 2mm in degrees Celsius
temp_4mm = num(:,15); % Temperatures at 4mm in degrees Celsius
temp_8mm = num(:,16); % Temperatures at 8mm in degrees Celsius

% Interpolate temperature at x = 0 mm for each time value using quadratic
interpolation
y = [2 4 8];
temp = [temp_2mm temp_4mm temp_8mm];
yq = 0;

N=length(t);
for i=1:N
    tempq4(i) = interp1(y, temp(i,:), yq, 'spline', 'extrap');
```

```
    if tempq4(i)<max(temp(i,:))
        tempq4(i)=max(temp(i,:));
    end
end
tempq4=tempq4(:);

% Plot temperature at x = 0 mm as a function of time
% figure;
% plot(t, tempq4);
% hold on
% plot(t, temp);
% hold off
% xlabel('Time (s)');
% ylabel('Temperature (C)');
% title('Temperature at x = 0 mm vs Time');

temp_2mm = num(:,18); % Temperatures at 2mm in degrees Celsius
temp_4mm = num(:,19); % Temperatures at 4mm in degrees Celsius
temp_8mm = num(:,20); % Temperatures at 8mm in degrees Celsius

% Interpolate temperature at x = 0 mm for each time value using quadratic
interpolation
y = [2 4 8];
temp = [temp_2mm temp_4mm temp_8mm];
yq = 0;

N=length(t);
for i=1:N
    tempq5(i) = interp1(y, temp(i,:), yq, 'spline', 'extrap');
    if tempq5(i)<max(temp(i,:))
        tempq5(i)=max(temp(i,:));
    end
end
tempq5=tempq5(:);

% Plot temperature at x = 0 mm as a function of time
%figure;
%plot(t, tempq5);
%hold on
%plot(t, temp);
%hold off
%xlabel('Time (s)');
%ylabel('Temperature (C)');
%title('Temperature at x = 0 mm vs Time');

% Find the first time when the temperature crosses 378
time =zeros(1,5);
found = false;
for i = 1:N
    if tempq1(i) >= 378
        found = true;
        break;
    end
end
```

```
if i ~= N
    time(1)=t(i);
end

found = false;
for i = 1:N
    if tempq2(i) >= 378
        found = true;
        break;
    end
end
if i ~= N
    time(2)=t(i);
end

found = false;
for i = 1:N
    if tempq3(i) >= 378
        found = true;
        break;
    end
end
if i ~= N
    time(3)=t(i);
end

found = false;
for i = 1:N
    if tempq4(i) >= 378
        found = true;
        break;
    end
end
if i ~= N
    time(4)=t(i);
end

found = false;
for i = 1:N
    if tempq5(i) >= 378
        found = true;
        break;
    end
end
if i ~= N
    time(5)=t(i);
end

time=time(:)
% Export temperature data to Excel file
output_data = [t tempq1 tempq2 tempq3 tempq4 tempq5];
xlswrite('surftemp_output.xlsx', output_data, 'Sheet1');
output_time=[time];
xlswrite('pyrolysistime.xlsx', output_time, 'Sheet1');
```

Script for temperature contours is presented below

```
clc
clear
% Load temperature data from Excel file
data = xlsread('Book.xlsx');
x = data(:,1); % x-axis values
y = data(:,2); % y-axis values
T = data(:,3:11); % temperature values
N=size(T,2);
% Reshape temperature data to a 2D array for contour plot
n = length(unique(y));
m = length(unique(x));
a=unique(x);
b=unique(y);

for k=1:N
    my_field = strcat('Tmatrix_',num2str(k));
    variable.(my_field) = reshape(T(:,k), n, m);;
    %T_matrix0 = reshape(T(:,k), n, m);
    [X,Y] = meshgrid(a,b);
    BDmatrix=variable.(my_field);
    newpoints = 100;
    [xq,yq] = meshgrid(linspace(min(a),max(a),newpoints
),linspace(min(b),max(b),newpoints));
    BDmatrixq = interp2(X,Y,BDmatrix,xq,yq,'spline');
    %[c,h]=contourf(xq,yq,BDmatrixq);
    % Create contour plot
    f=figure;

    [c,h]=contourf(xq,yq,BDmatrixq,'edgecolor','none');
    caxis([25.36,718.88])
    c = jet();
    colormap(c);
    colorbar;
    xlabel('Length (mm)');
    ylabel('Thickness (mm)');
    title('Temperature Contour Plot');
    saveas(f, strcat('Test3_',num2str(k)),'png');
end
```