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Q.1

(a) Plot Temperature Vs Distance curve in Mold at different time.

Code:

```
clear all
clc
Tm = 1000; % melting Temperature
T0 = 300;  % Ambient Temperature
tn = 1000;  % Total Time
dt = 2;   %Time Step
xn = 120;  %length of mold
alpha = 1;
dx = 2;
k = alpha*dt/(dx^2); % must be less then or equal to 0.5
T = zeros(xn+1,tn);
k = 0.3;
a = 1:xn-1;
for i = 1:tn
    T(1,i) = Tm;
end
for i = 2 : xn+1
    T(i,1) = T0;
end
for t = 1:tn-1
 for x = 2:xn-1
   T(x,t+1) = T(x,t) + k*(T(x+1,t)-2*T(x,t)+T(x-1,t));
 end
 T(xn,t+1) = T(xn,t)+k*(T0 - 2*T(xn,t)+T(xn-1,t));
end
xa = [0:-1:-(xn-1)];
a(1) = 1000;
for j = 1 : dt : tn
  for i = 2:xn
     a(i) = T(i,j);
  end
  figure(1), clf
  plot(xa,a,'-r+','Linewidth',1,'Markersize',5);
  xlabel('Distance(m)');
  ylabel('Temperature(degree Celsius)');
  title(['Temperature Vs Distance Curve in Mold at time : ',num2str(j)]);
  drawnow
end
```

Algorithm :

At any time t value of T at x = 0 is Tm(melting temp.).And at t = 0 for any x > 0 value T is T0(temp. of mold).After that we just used the formula to get values at T(x,t+Δt) using values of T(x,t), T(x +Δx , t), T(x,t), T(x-Δx,t).we used 1d array a to copy the elements of 2d array T at a particular time t and ploted it's graph with xa.where xa is an array of size xn-1 with values 0 to -(xn-1).

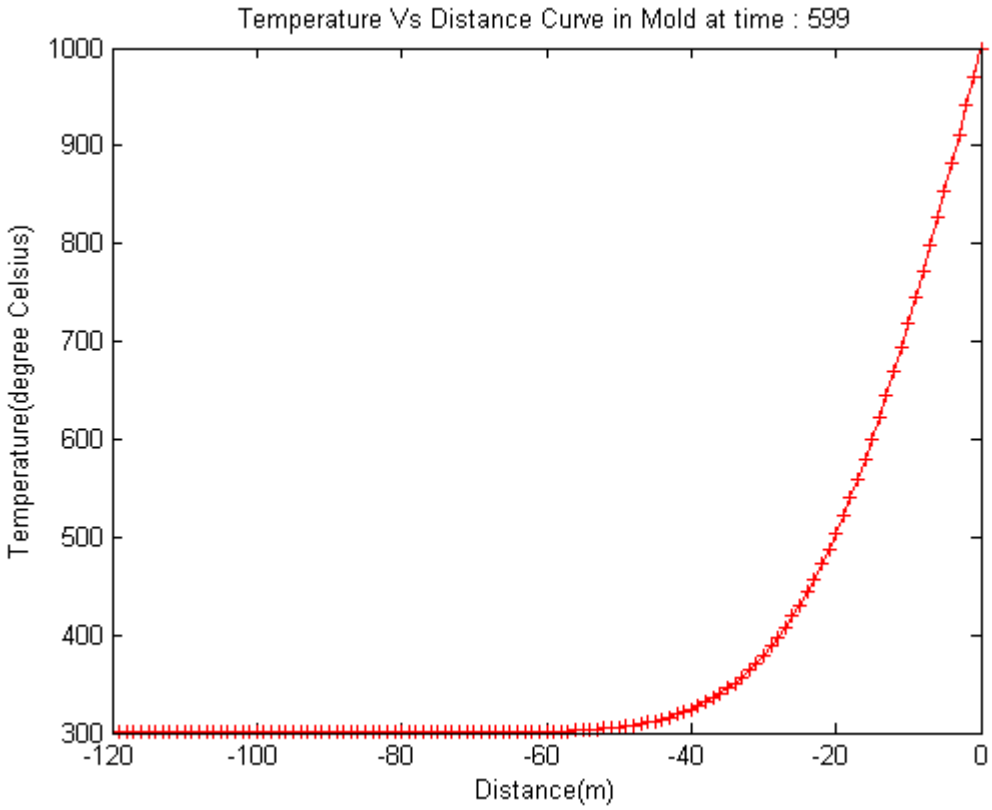
Formula Used :

- dT/dt = α (d^2)T/dx^2 , where alpha is heat diffusivity.
- (d^2)T/dx^2 = [T(x +Δx , t) – 2*T(x,t)+T(x-Δx,t)]/(Δx^2).

- dT/dt = [T(x,t+Δt)-T(x,t)]/Δt.
- T(x,t+Δt) = T(x,t)+k.(T(x +Δx , t) – 2*T(x,t)+T(x-Δx,t)).
- k = (Δt*α)/(Δx^2).
- The value of k should be less than or equal to 0.5.

Time-Complexity : O(tn*xn) where tn is total time and xn is mold length.

Graph :



(b) Solidification Thickness Vs Time curve for Mold .

Code:

```
Tm = 1000;    %melting point of mold (K)
T0 = 300;     %Ambient Temperature (K)
Ps = 2700;    %density of metal(Aluminium) (Kg/m^3)
H = 398;      %heat of fusion(Aluminium)  ( Kj/Kg)

Pm = 7600;    %density of mold(mild steel) (Kg/m^3)
Km = 50.2;    %Thermal Conductivity(mild steel) W/(m.K)
Cm = 510.78; %Specific Heat(J/(Kg.K))

t = 1 : 100;

s = (2/sqrt(pi))*((Tm-T0)/(Ps*H))*sqrt(Km*Pm*Cm)*sqrt(t);
figure(1)
plot(t,s,'-r*','Linewidth',2,'Markersize',3);
```

```
  xlabel('t(seconds)');ylabel('S(m)'),title('Solidification thickness Vs
Time');
  figure(2)
  plot(sqrt(t),s,'-b+','Linewidth',2,'Markersize',3);
  xlabel('sqrt(t)');ylabel('S(m)'),title('Solidification thickness vs
sqrt(Time)');
  figure(3)
  plot(t,s,'-r*','Linewidth',2,'Markersize',3);
  xlabel('t');
  ylabel('S');
  hold on
  plot(sqrt(t),s,'-b+','Linewidth',2,'Markersize',3);
```

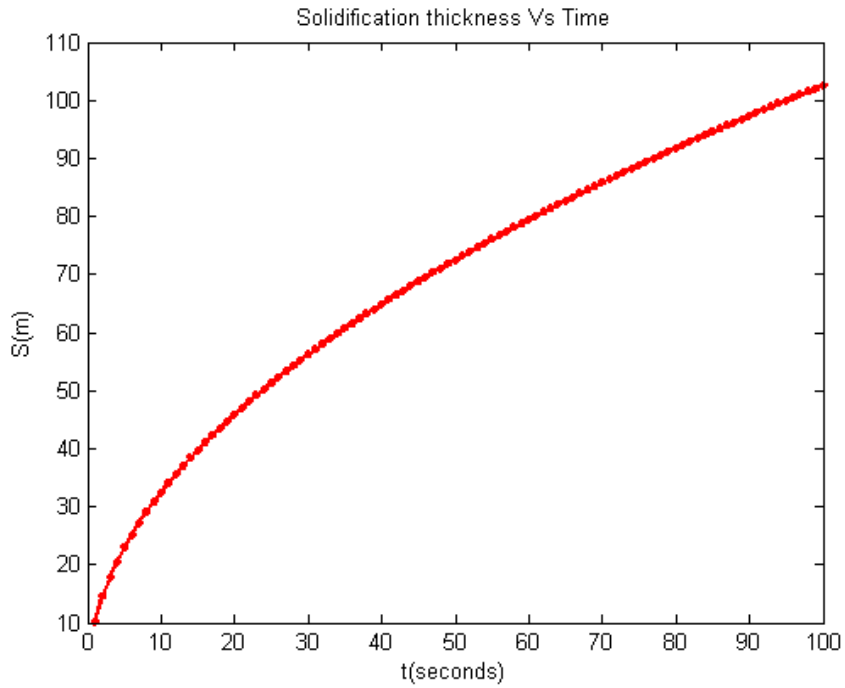
Algorithm :

Ploted graph of an array t with S using the formula given below:

1.

$$S = \frac{2}{\sqrt{\pi}} \underbrace{\left(\frac{T_M - T_0}{\rho_s H} \right)}_{\text{Metal}} \underbrace{\sqrt{K_m \rho_m c_m}}_{\text{Mold}} \sqrt{t}$$

2. Graph for Solidification Thickness Vs Time :



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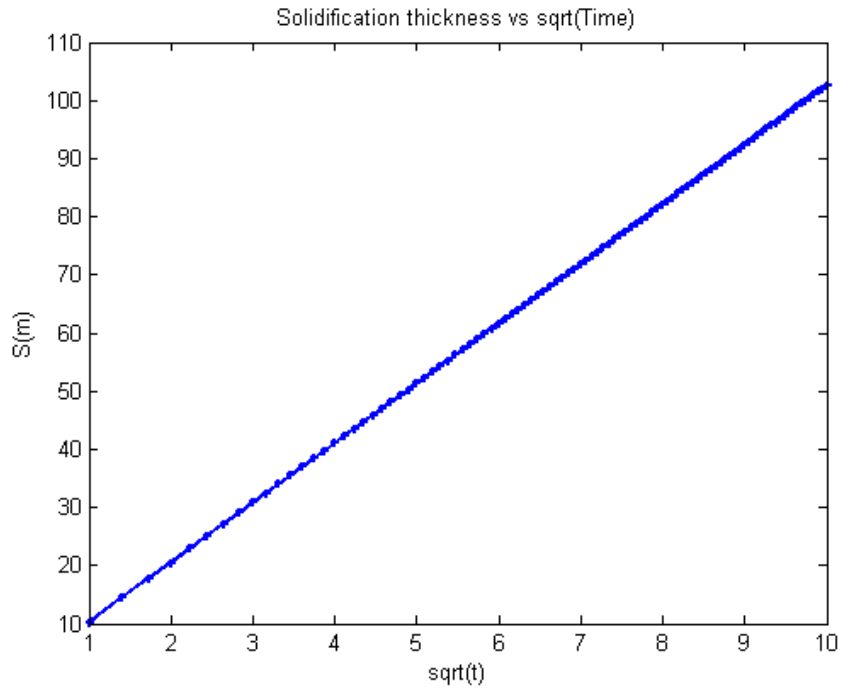
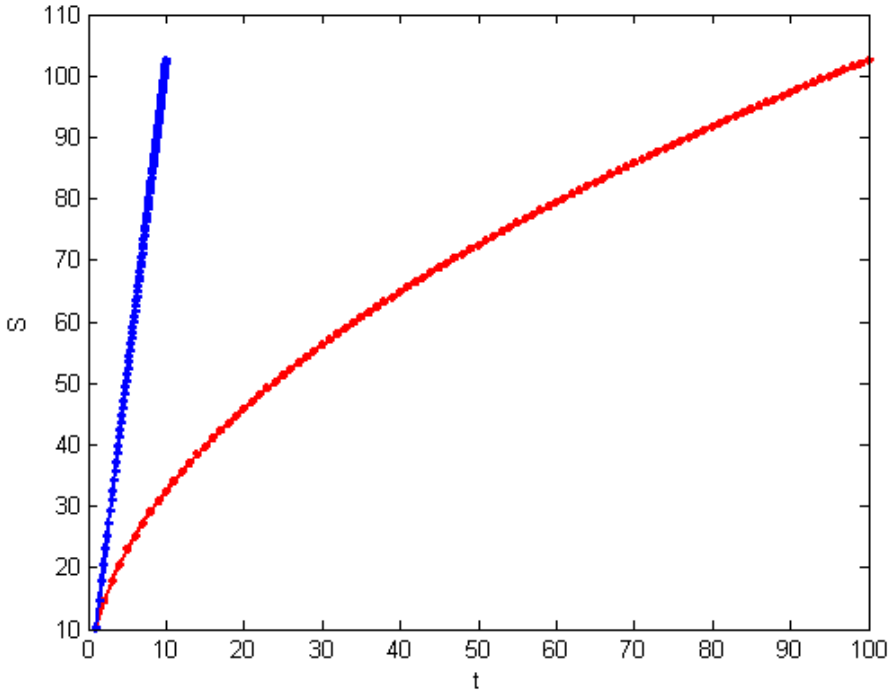
3. Graph for Solidification Thickness Vs sqrt(Time) :



4. Graph for Solidification Thickness Vs sqrt(Time) and time merged together:



Time-Complexity : O(n) ,where n is the range of t.