# MULTIRATE WELL TEST
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## 1. Abstract

This study aims to find wellbore pressure profile against time in a multi rate well test. Two ways to approximate the value of wellbore pressure are numerical using superposition theory and analytical using radial diffusivity equation.

## 2. Objective

Objective of this assignment is as follows :

1. To find wellbore pressure profile in a multi rate well test simulation with 5 different rates.
2. To understand the effect of sensitivity in each parameter.
3. To compare the result from superposition theory and radial diffusivity equation.

## 3. Numerical Approach :

Consider a reservoir model possesses these following parameters :

| | | | |
|---|---|---|---|
| Wellbore radius: | 25 cm | Skin Factor | Zero |
| Reservoir thickness | 100 m | Oil viscosity | 0.02 Pa.s |
| Reservoir permeability | $10^{-12}$ $m^2$ | Oil Density | 900 $kg/m^3$ |
| Initial pressure | $1.5x10^7$ Pa | Porosity | 25% |
| Effective compressibility | $2x10^{-9}$ $Pa^{-1}$ | | |

This reservoir is undergoing a multi rate well test with 5 different rates and certain period of test :

| Number | Q ($m^3$/d) | T (days) |
|---|---|---|
| 1 | 0.02 | 3 |
| 2 | 0 | 6 |
| 3 | 0.004 | 2 |
| 4 | 0.009 | 4 |
| 5 | 0.01 | 2 |

Multi rate simulator will process the input values and displayed in figure 1 in Appendix A. Figure 2 give the wellbore pressure profile along well test period as displayed in figure 2.

A sensitivity study has been conducted by changing these 9 parameters in table 1 by 20% above and below its initial value. From these 9 parameter, initial pressure or Pi give the most significant change among them all.

The second most significant are changes in permeability, thickness, and viscosity. Since permeability and thickness are proportional to pressure drop, the more permeable or thicker the reservoir, the less pressure drop in wellbore. However, the more viscous, the more pressure drop in the wellbore. The other parameters i.e. compressibility and porosity give less contribution to pressure drop. Whilst, pressure drop is not affected by density. Those effects can be seen in figure 3 to figure 10.

All matlab script in this simulator are displayed in appendix B and C.

## 4. Conclusions :

Several conclusion can be drawn from this assignment. Those are as follows :

1. Higher rate, will result lower wellbore pressure. Inversely, lower rate will result higher wellbore pressure. Wellbore pressure tends to reach its initial value if the well is shut down or zero rate.
2. Wellbore pressure never reaches its initial pressure although shutting the well for a period of time.
3. By changing parameter value 20% above and below its initial value, the most significant parameter is initial pressure. The second are permeability, viscosity, and thickness. Other parameters give less change.

## APPENDIX A : FIGURES

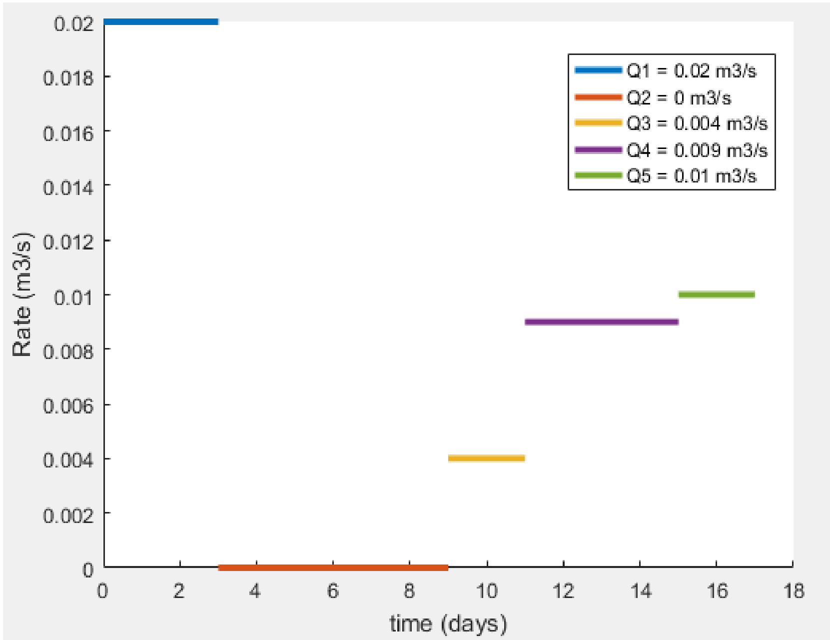


*Figure 1 : Plot Flow rate vs Time in certain period*

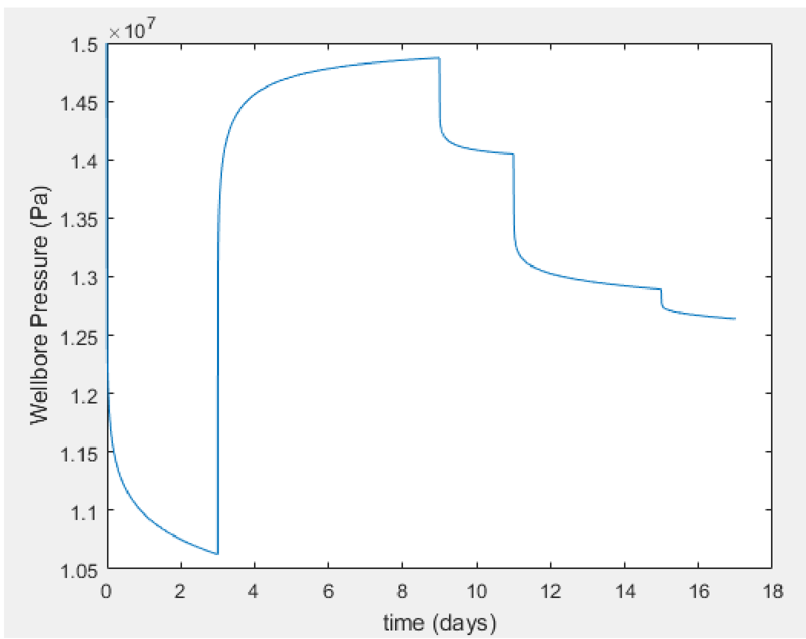


*Figure 2 : plot wellbore pressure vs time in certain period*

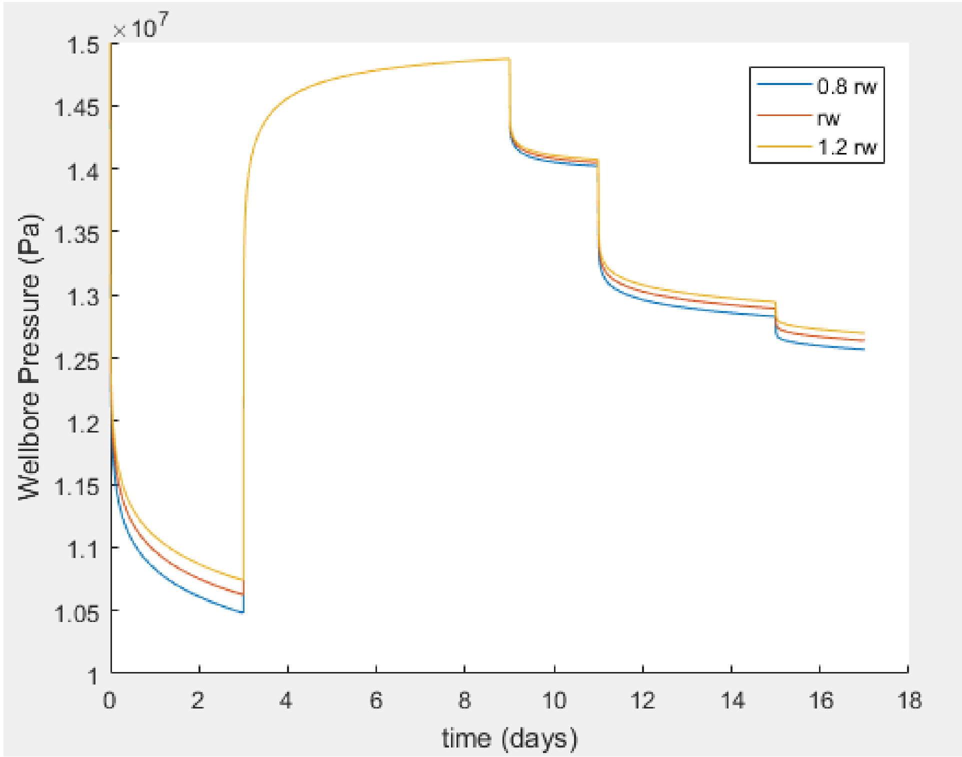


*Figure 3 : effect of change in reservoir thickness toward wellbore pressure*

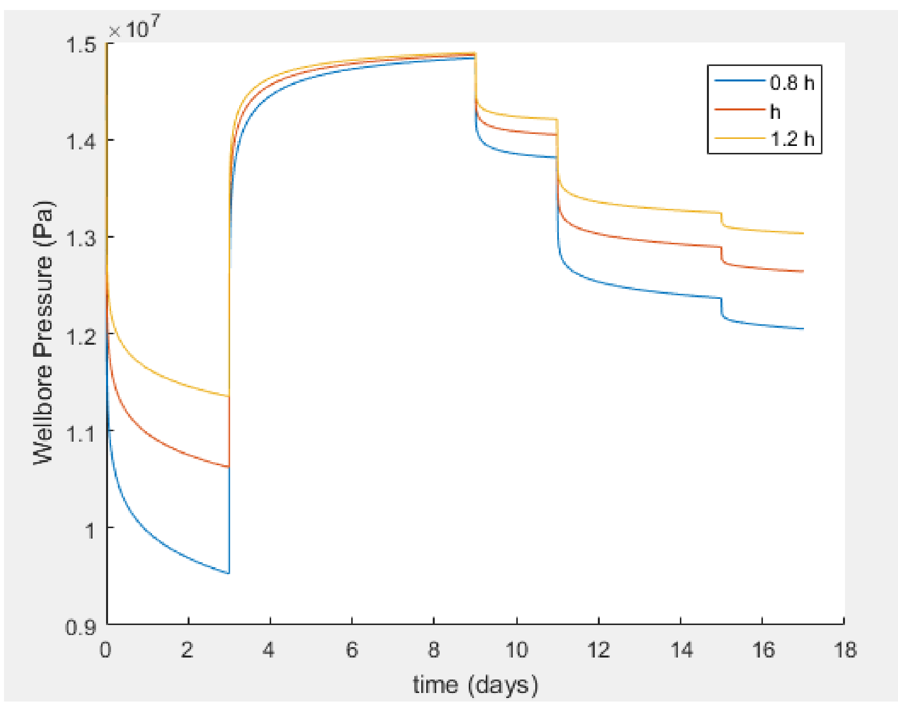


*Figure 4 : effect of change in reservoir thickness toward wellbore pressure*

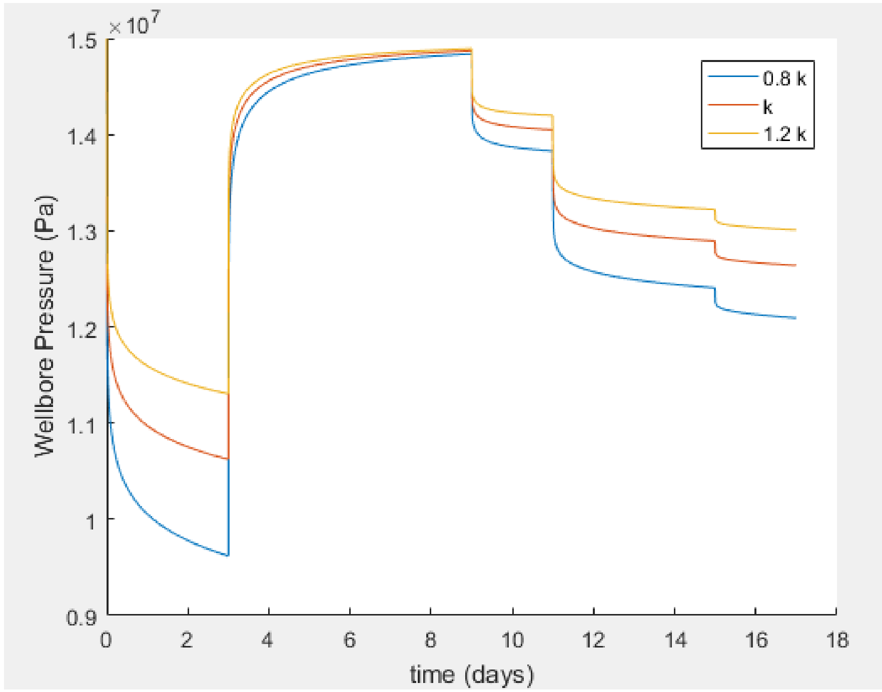


*Figure 5 : effect of change in permeability toward wellbore pressure*

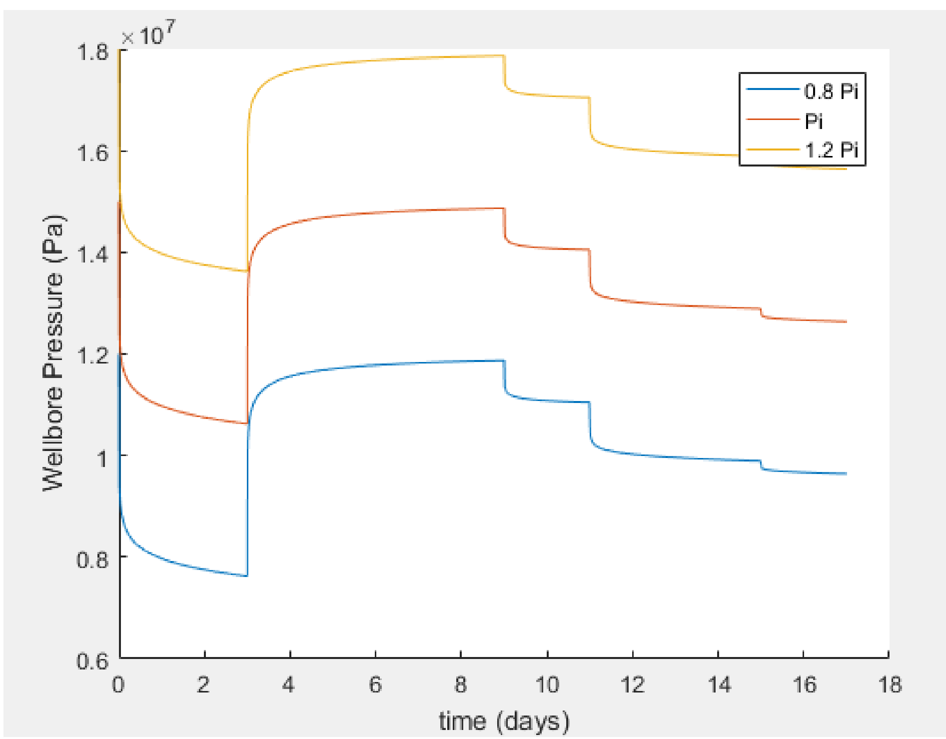


*Figure 6 : effect of change in initial pressure toward wellbore pressure*

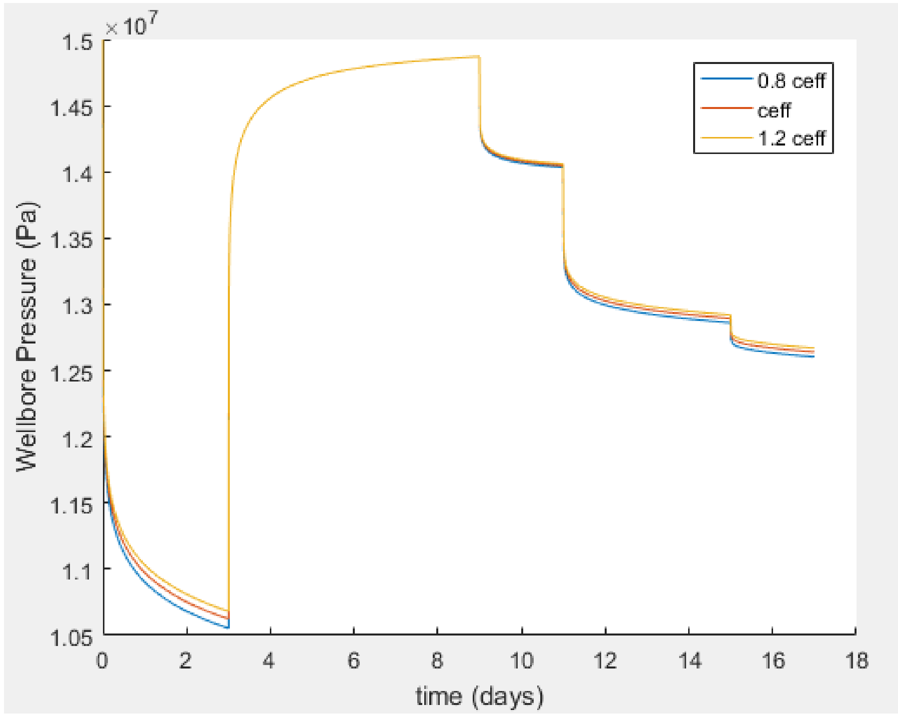


*Figure 7 : effect of change in compressibility toward wellbore pressure*

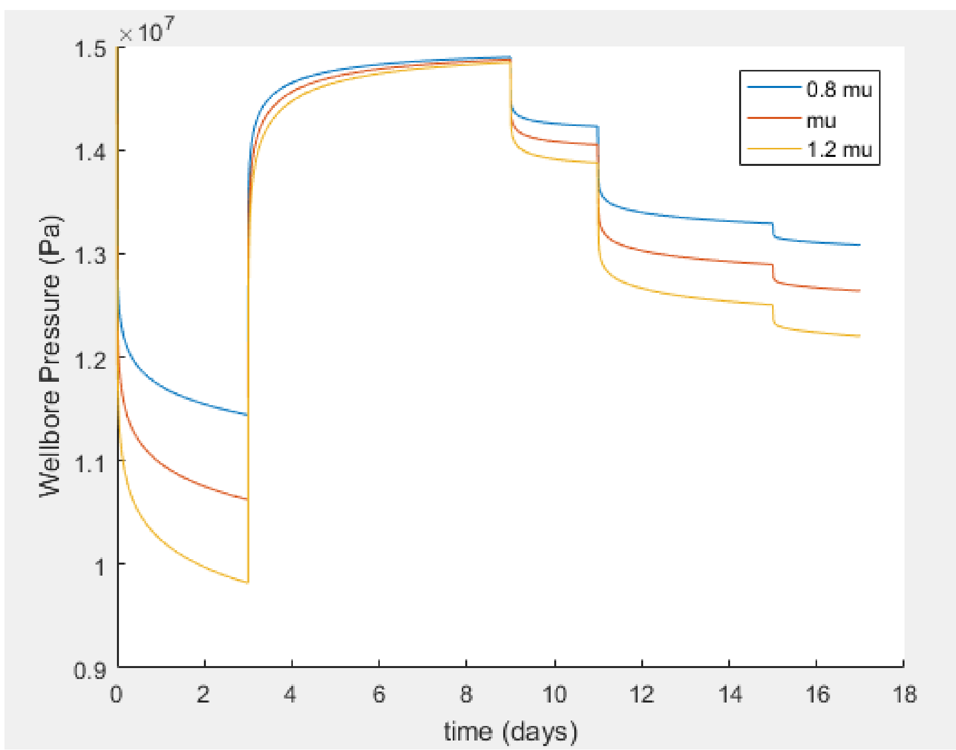


*Figure 8 : effect of change in viscosity toward wellbore pressure*

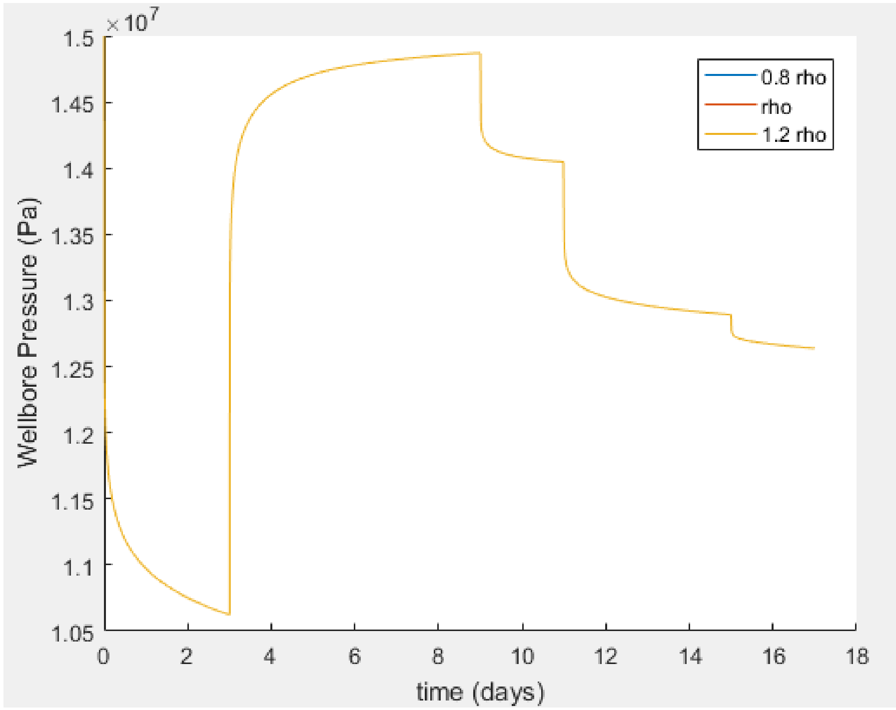


*Figure 9 : effect of change in density toward wellbore pressure*

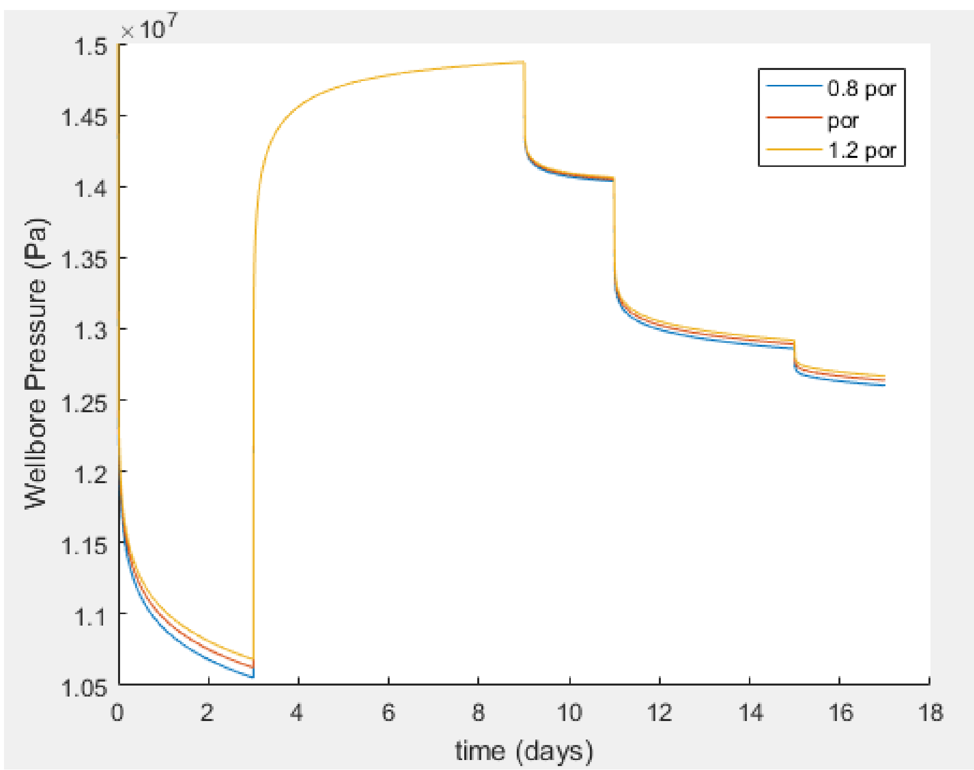


*Figure 10 : effect of change in porosity toward wellbore pressure*

## APPENDIX B : MATLAB SCRIPT

```
% Multirate Well Testing
% R B Arbarim : 4573900

clear all

disp('Multi Rate Test Simulator by RB Arbarim - 4573900')
disp(' ')
for i = 1 : 5
       fprintf('Q%s\n',num2str(i))
       q(i) = str2double(input('enter rate in m3/s (recommended value not
more than 0.02 m3/s) = ','s'));
       t(i) = str2double(input('how long does it last in days = ','s'));
end

% q = [0.0200 0 0.0040 0.0090 0.0100];
% t = [3     6     2     4     2];
conv = 86400; % conversion from day to second
t1 = conv.*t; % s
t2 = cumsum(t1);
t3 = 1:sum(t1);
t4 = [ 0 t3./conv];

rw = 0.25; % m
h = 100; % m
k = 10^-12; % m2
Pi = 1.5*10^7; % m2
ceff = 2*10^-9; % Pa^-1
S = 0;
visc = 0.02; % Pa.S
dens = 900; % kg/m
por = 0.25;
Bo = 1; % Rm3/STm3
gamma = exp(0.5722);

A = (visc*Bo)/(4*pi*k*h);
B = (4*k)/(gamma*por*visc*ceff*rw^2);

a = cell(length(q),1);
figure(1)
for i = 1 : length(q)
    hold on
        if i == 1
            Q(i,1:sum(t1)) = q(i);
            plot((1:t2(i))./conv,Q(i,i:t2(i)),'linewidth',3);
        else
            Q(i,(t2(i-1)):sum(t1)) = q(i);
            plot((t2(i-1):t2(i))./conv,Q(i,t2(i-1):t2(i)),'linewidth',3 );
        end
    a{i} = ['Q' num2str(i) ' = ' num2str(q(i)) ' m3/s'];
end

legend(a)
xlabel('time (days)')
```

```
ylabel('Rate (m3/s)')
hold off

for i = 1 : length(t3)
    if i <= t2(1)
        pw(i) =  - A*q(1)*log(S+B*t3(i));
    elseif i <= t2(2) && i > t2(1)
        pw(i) = - A*q(1)*log(S+B*t3(i)) -A*(q(2)-q(1))*log(S+B*(t3(i)-
t2(1)));
    elseif i <= t2(3) && i > t2(2)
        pw(i) = - A*q(1)*log(S+B*t3(i)) -A*(q(2)-q(1))*log(S+B*(t3(i)-
t2(1)))-A*(q(3)-q(2))*log(S+B*(t3(i)-t2(2)));
    elseif i <= t2(4) && i > t2(3)
        pw(i) = - A*q(1)*log(S+B*t3(i)) -A*(q(2)-q(1))*log(S+B*(t3(i)-
t2(1)))-A*(q(3)-q(2))*log(S+B*(t3(i)-t2(2)))-A*(q(4)-q(3))*log(S+B*(t3(i)-
t2(3)));
    elseif i <= t2(5) && i > t2(4)
        pw(i) = - A*q(1)*log(S+B*t3(i)) -A*(q(2)-q(1))*log(S+B*(t3(i)-
t2(1)))-A*(q(3)-q(2))*log(S+B*(t3(i)-t2(2)))-A*(q(4)-q(3))*log(S+B*(t3(i)-
t2(3)))-A*(q(5)-q(4))*log(S+B*(t3(i)-t2(4)));
    end
end

figure(2)
Pw = [ Pi (Pi+pw)];
plot(t4,Pw)
xlabel('time (days)')
ylabel('Wellbore Pressure (Pa)')

disp(' ')
disp('do sensitivity plus and minus 20% of its initial value');
disp('press 1 to do sensitivity in wellbore radius (rw)')
disp('press 2 to do sensitivity in reservoir thickness (h)')
disp('press 3 to do sensitivity in permeability (k)')
disp('press 4 to do sensitivity in initial pressure (Pi)')
disp('press 5 to do sensitivity in compressibility (Ceff)')
disp('press 6 to do sensitivity in skin (S)')
disp('press 7 to do sensitivity in viscosity (mu)')
disp('press 8 to do sensitivity in density (rho)')
disp('press 9 to do sensitivity in porosity')
x = str2double(input('which parameter (1 to 9) do you want to do sensitivity?
= ','s'));
disp('see figure 3 for the sensitivity result')

Pw_sens = sensitivity(q,t2,t3,x);
b = cell(9,3);
b(1,1:3) = {'0.8 rw' , 'rw' , '1.2 rw'};
b(2,1:3) = {'0.8 h' , 'h' , '1.2 h'};
b(3,1:3) = {'0.8 k', 'k' , '1.2 k'};
b(4,1:3) = {'0.8 Pi' , 'Pi' , '1.2 Pi'};
b(5,1:3) = {'0.8 ceff' , 'ceff',  '1.2 ceff'};
b(6,1:3) = {'0.8 S',  'S',  '1.2 S'};
b(7,1:3) = {'0.8 mu',  'mu',  '1.2 mu'};
b(8,1:3) = {'0.8 rho' , 'rho',  '1.2 rho'};
b(9,1:3) = {'0.8 por' , 'por' , '1.2 por'};
```

```
figure(3)
hold on
for i = 1 : 3
    plot(t4,Pw_sens(i,:))
end
hold off

xlabel('time (days)')
ylabel('Wellbore Pressure (Pa)')
legend(b(x,:))
```

# APPENDIX C : FUNCTION FILE FOR SENSITIVITY

```
function Pw_sens = sensitivity(q,t2,t3,x)
rw = 0.25; % m
h = 100; % m
k = 10^-12; % m2
Pi = 1.5*10^7 ; % m2
ceff = 2*10^-9; % Pa^-1
S = 0;
visc = 0.02; % Pa.S
dens = 900; % kg/m
por = 0.25;
gamma = exp(0.5722);

sens1 = [rw;h;k;Pi;ceff;S;visc;dens;por];
sens = [sens1 sens1 sens1];
sens(x,:) = [0.8*sens(x,1) sens(x,2) 1.2*sens(x,3)];

S = [ 0 0 0];
Pi= [1.5*10^7 1.5*10^7 1.5*10^7];
if x == 6
    S = [1 2 3];
elseif x == 4
    Pi = [0.8*1.5*10^7 1.5*10^7 1.2*1.5*10^7];
end

pw_sens =zeros(length(q),length(t3));
for i= 1 : 3
    A(i) = (sens(7,i))/(4*pi.*sens(3,i).*sens(2,i));
    B(i) =
(4.*sens(3,i))/(gamma.*sens(9,i).*sens(7,i).*sens(5,i).*sens(1,i).^2);
for j = 1 : length(t3)
    if j <= t2(1)
        pw_sens(i,j) =  - A(i)*q(1)*log(S(i)+B(i)*t3(j));
    elseif j <= t2(2)  && j > t2(1)
        pw_sens(i,j) = - A(i)*q(1)*log(S(i)+B(i)*t3(j)) -A(i)*(q(2)-
q(1))*log(S(i)+B(i)*(t3(j)-t2(1)));
    elseif j <= t2(3)  && j > t2(2)
        pw_sens(i,j) = - A(i)*q(1)*log(S(i)+B(i)*t3(j)) -A(i)*(q(2)-
q(1))*log(S(i)+B(i)*(t3(j)-t2(1)))-A(i)*(q(3)-q(2))*log(S(i)+B(i)*(t3(j)-
t2(2)));
    elseif j <= t2(4)  && j > t2(3)
        pw_sens(i,j) = - A(i)*q(1)*log(S(i)+B(i)*t3(j)) -A(i)*(q(2)-
q(1))*log(S(i)+B(i)*(t3(j)-t2(1)))-A(i)*(q(3)-q(2))*log(S(i)+B(i)*(t3(j)-
t2(2)))-A(i)*(q(4)-q(3))*log(S(i)+B(i)*(t3(j)-t2(3)));
    elseif j <= t2(5)  && j > t2(4)
        pw_sens(i,j) = - A(i)*q(1)*log(S(i)+B(i)*t3(j)) -A(i)*(q(2)-
q(1))*log(S(i)+B(i)*(t3(j)-t2(1)))-A(i)*(q(3)-q(2))*log(S(i)+B(i)*(t3(j)-
t2(2)))-A(i)*(q(4)-q(3))*log(S(i)+B(i)*(t3(j)-t2(3)))-A(i)*(q(5)-
q(4))*log(S(i)+B(i)*(t3(j)-t2(4)));
    end
end
Pw_sens(i,1:length(t3)+1) = [ Pi(i) (Pi(i)+pw_sens(i,:))];

end
return
```