AKA PEACE OTAOGHENE 18/Eng01/002

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CHEMICAL ENGINEERING
Mixing
1200 gal of water } dissolved initially
150 Lb of Salt }
50 gal of brine [mixture of Salt & water] each contain (1+Sint) Lb of Salt
30 gal/min removes from the tank
Denoting the amount of Salt in the tank at any time t as m
Therefore $\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out}$

Since 50gal enters per minute, and one gallon contains (1+Sint) Lb of Salt. Therefore the amount of salt leaving the tank

$$\dot{m}_{in} = \frac{50\,gal}{min} \times (1+Sint)\frac{Lb}{gal}$$

$$\dot{m}_{in} = 50(1+Sint)\frac{Lb}{min}$$

The tank contains 1200gal of water with dissolved Salt, and 30 gal of the Solutions leaves the tank per minute

$\frac{30\,gal}{1200\,gal} = 0.025 = 2.5\%$ of the content of the tank. If that's the case, 2.5% of Salt present in the tank will also leave the tank per minute, $\therefore m_{out} = 2.5\%$ of m

$$\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out}$$
$$\frac{dm}{dt} = 50(1+Sint) - 2.5\% \text{ of } m.$$
$$\frac{dm}{dt} = 50(1+Sint) - 0.025m$$

b. $\frac{dm}{dt} = 50(1+Sint) - 0.025m$

$$\frac{dm}{dt} + 0.025m = 50(1+Sint)$$

Using the Integrating factor method.

$\frac{dy}{dx} + Py = Q$; $\frac{dm}{dt} + Pm = Q$.

Where $P = 0.025$, $Q = 50(1 + \sin t)$

$\int P dt = 0.025t$ $\quad If = e^{\int P dt}$

$If = e^{0.025t}$

$M \cdot If = \int Q \cdot If \, dt$

$m \cdot e^{0.025t} = \int 50(1 + \sin t) \cdot e^{0.025t} \, dt$

$me^{0.025t} = 50 \int (1 + \sin t) \cdot e^{0.025t} \, dt$.

$me^{0.025t} = 50 \int e^{0.025t} + 50 \int e^{0.025t} \sin t \, dt$

$me^{0.025t} = 50 \cdot \frac{e^{0.025t}}{0.025} + 50 \int e^{0.025t} \sin t \, dt$ ---①

Integrating $\int e^{0.025t} \sin t \, dt$.

Integration by part is used. $\int u dv = uv - \int v du$

$u = e^{0.025t}$ $\quad dv = \sin t$

$du = 0.025 e^{0.025t}$ $\quad v = -\cos t$

$\int e^{0.025t} \sin t = e^{0.025t} \cdot -\cos t - \int -\cos t \cdot 0.025 e^{0.025t}$

$\int e^{0.025t} \sin t = -e^{0.025t} \cos t + 0.025 \int \cos t \, e^{0.025t} \cos t$. ---②

Using Integration by for $\int e^{0.025t} \cos t$

$u = e^{0.025t}$, $\quad dv = \cos t$.

$du = 0.025 e^{0.025t}$, $\quad v = \sin t$.

$\therefore \int e^{0.025t} \cos t = e^{0.025t} \sin t - \int \sin t \cdot 0.025 e^{0.025t}$

$\int e^{0.025t} \cos t = e^{0.025t} \sin t - 0.025 \int e^{0.025t} \sin t$ ---③

Therefore put eqn 3 in 2.

$\int e^{0.025t} \sin t = -e^{0.025t} \cos t + 0.025 [e^{0.025t} \sin t - 0.025 \int e^{0.025t} \sin t]$

$\int e^{0.025t} \sin t = -e^{0.025t} \cos t + 0.025 [e^{0.025t} \sin t - 0.025 \int e^{0.025t} \sin t$.

Let $Q = \int e^{0.025t} \sin t$

$Q = \int e^{0.025t} \cos t + 0.025 [e^{0.025t} \sin t - 0.025 Q]$

$Q = \int e^{0.025t} \cos t + 0.025 e^{0.025t} \sin t - 6.25 \times 10^{-4} Q$

$Q + 6.25 \times 10^{-4} Q = -e^{0.025t} \cos t + 0.025 e^{0.025t} \sin t$

$1.000625 Q = -e^{0.025t} \cos t + 0.025 e^{0.025t} \sin t$

$1.000625Q = -e^{0.025t}(\cos t - 0.025\sin t)$

$Q = \frac{-e^{0.025t}}{1.000625}(\cos t - 0.025\sin t)$

Recall $Q = \int 0.025 \int e^{0.025t}\sin t$

$\int e^{0.025t}\sin t = \frac{-e^{0.025t}}{1.00625}(\cos t - 0.025\sin t) + C \cdots (5)$

Put eqn 5 in 1

$me^{0.025t} = \frac{50e^{0.025t}}{0.025t} + 50\left[\frac{-e^{0.025t}}{1.000625}(\cos t - 0.025\sin t) + 50C\right]$

$me^{0.025t} = \frac{50e^{0.025t}}{0.025t} - \frac{50e^{0.025t}}{1.00625}(\cos t - 0.025\sin t) + 50C$

Divide both sides by $e^{0.025t}$

$m = \frac{50}{0.025} - \frac{50}{1.000625}(\cos t - 0.025\sin t) + \frac{50C}{e^{0.025t}}$

$m = 2000 - 49.9687(\cos t - 0.025\sin t) + \frac{50}{e^{0.025t}}C \cdots (6)$

Now: When $m = 150$, $t = 0$.

$150 = 2000 - 49.9687(\cos(0) - 0.025\sin(0)) + \frac{50}{e^{0.025(0)}}C$

$150 = 2000 - 49.9687(1 - 0) + 50C$

$150 = 1950.0313 + 50C$

$150 - 1950.0318 = 50C$

$C = \frac{150 - 1950.0313}{50}$

$C = -36.000626$

$C \approx -36$

Put $C = 36$ in eqn 6

$m = 2000 - 49.9687(\cos t - 0.025\sin t) + \frac{50}{e^{0.025t}}(-36)$

$m = 2000 - 49.9687(\cos t - 0.025\sin t) - \frac{1800}{e^{0.025t}}$

```
commandwindow
clear
clc
close all
syms m(t)
mout = 0.025*m
min = 50*(1 + sin(t))
m = dsolve(diff(m, t) == min - mout, m(0) == 150)

step_hour = 0.5/60
t = 0:step_hour:7.5
m_values = subs(m, t*60)

plot(t, m_values)
grid on
grid minor
xlabel('time(hour)')
ylabel('Amount of Salt (lb)')
```

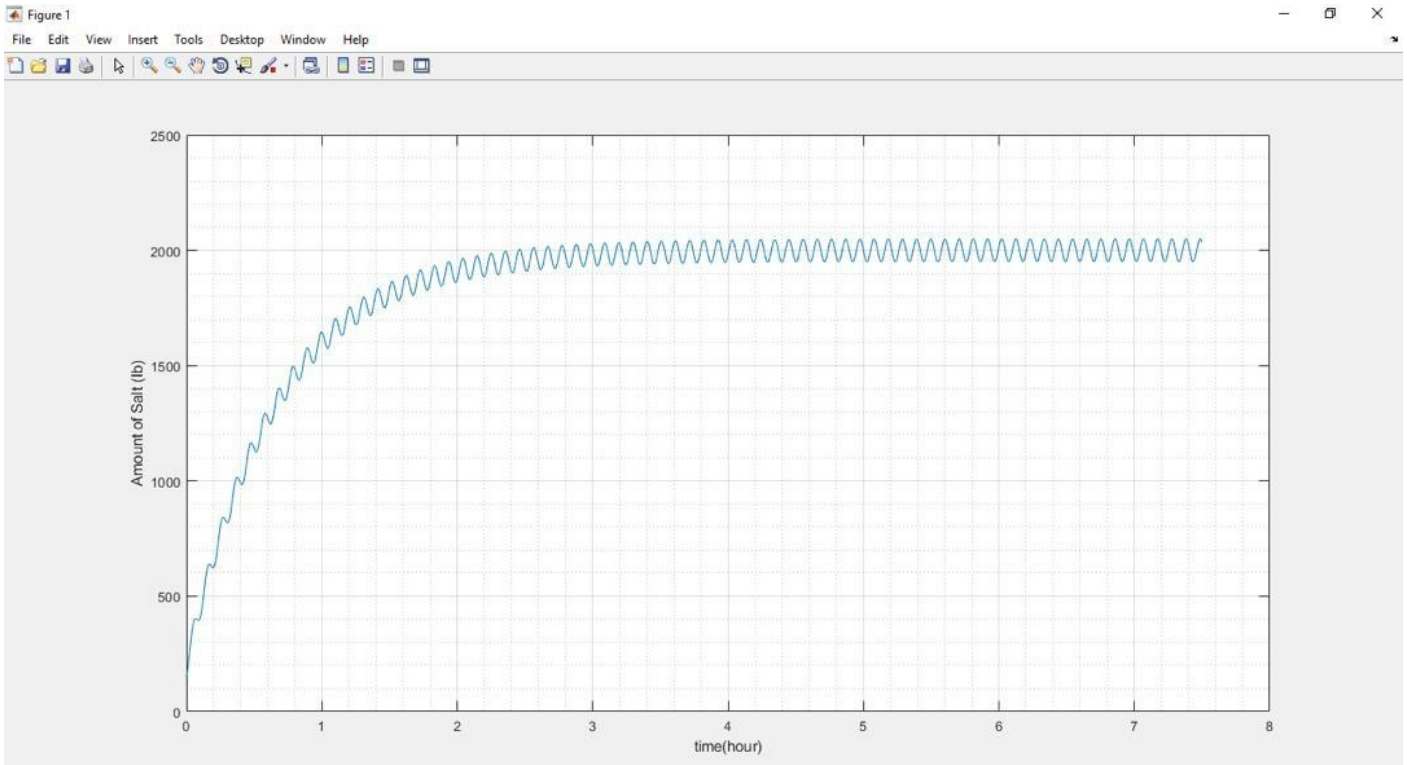
```
Command Window

    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000

  Columns 493 through 501

    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000

fx >>
```




```
commandwindow
clear
clc
close all
t=1:2:500;
y=((50/0.05) + ((50/1.0025)*sin(t)) + (((50*0.05)/1.0025)*cos(t)) - (802.49*exp(-0.05*t)))
tm=0:2:500;
ym=((1000)-(800*exp(-0.05*tm)))
T=[t,tm]
Y=[y,ym]
plot(T,Y,'green')
grid on
grid minor
xlabel('T(min)')
ylabel('V(litre)')
col_header={'t(min)','V(Litre'};
xlswrite('odevbesdata.xlsx',[T(:),Y(:)],'veriler','A2');
xlswrite('odevbesdata.xlsx',col_header,'veriler','A1');
```

```
Command Window

    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000

  Columns 493 through 501

    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000

fx >>
```

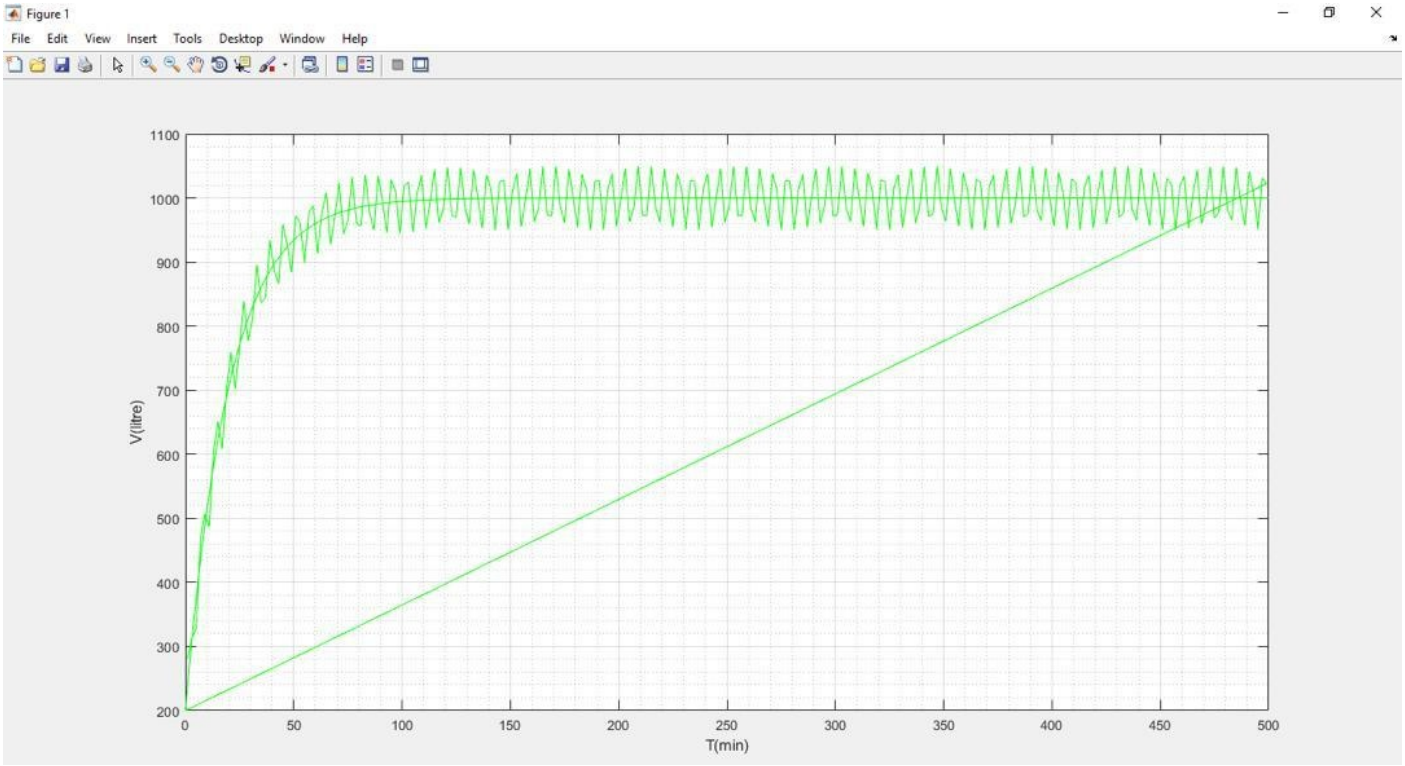


Figure 1
File Edit View Insert Tools Desktop Window Help
1100
1000
900
800
700
600
500
400
300
200
V(litre)
0
50
100
150
200
250
300
350
400
450
500
T(min)