OGOMMUEGBUNAM FAVOUR CHIDI

17/ENG01/021

CHEMICAL ENGINEERING

ASSIGNMENT 4 ENG 282

It is discovered that $600 ft^3/min$ of fresh air flows into a room containing $20000 ft^3$ of air. The mixture, which is made practically uniform by circulating fans, is exhausted at a rate of 600 cubic feet per minute (ft^3/m). If the room contains no fresh air initially,

(a) develop a model for the amount of fresh air in the room at any time t,

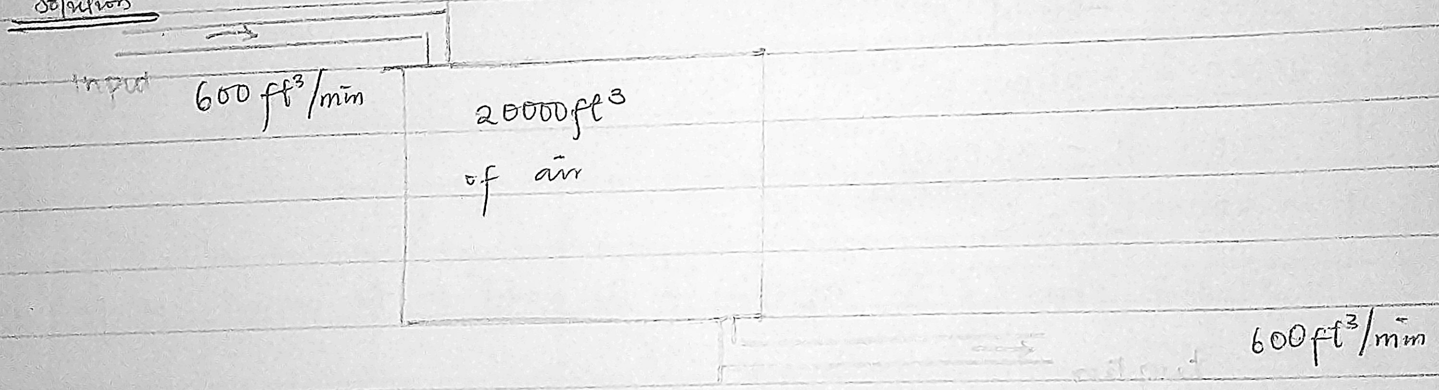
(b) Calculate the time at which 90% of the air in the room will become fresh

(c) with the aid of MATLAB, plot the dynamic response of the amount of fresh air in the room for t=0 to t=6hr using a step time of 5min.

(d) determine the steady state value of the amount of fresh air in the room

(e) Comment on the result obtained in (d).

Solution



Let y be the amount of air at time t in (ft^3) in the room

$\frac{dy}{dt}$ = air in flow rate - fresh air out flow rate

fresh air in flow → ~~600ft³/min~~ $600 ft^3/min$

fresh air out flow rate → $\frac{600}{20000} = 0.03$ min

$$\frac{dy}{dt} = 600 - 0.03y$$

$$= -0.03y + 600$$

$$= -0.03(y - 20000)$$

$\frac{dy}{dt} = -0.03(y - 20000)$

$dy \frac{1}{(y-20000)} = -0.03dt$

$\ln(y - 20000) = -0.03t + c$

$y - 20000 = e^{-0.03t + c}$

$y - 20000 = e^{-0.03t} \cdot e^{c}$

where e^c is initial condition y_0.

$y - 20000 = e^{-0.03t} y_0$

$y - 20000 = y_0 e^{-0.03t}$

at $t = 0$, $y = 0$

$y - 20000 = y_0 e^{-0.03t}$

$0 - 20000 = y_0 e^{-0.03(0)}$

$-20000 = y_0$

substituting $y_0 = -20000$ into the initial equation

$y - 20000 = ~~20~~ y_0 e^{-0.03t}$

$y - 20000 = -20000 e^{-0.03t}$

$y = 20000 ~~+~~ - 20000 e^{-0.03t}$

$y = 20000(1 - e^{-0.03t})$

The equation above is the equation of for the model for the amount of fresh air in the room

(b) $90\% = 90/100 = 0.9$

$y = 0.9$ of 20000

$= 0.9 \times 20000 = 18000 ft^8$

$18000 = 20000(1 - e^{-0.03t})$

~~0.9~~ = $0.9 = 1 - e^{-0.03t}$

$e^{-0.03t} = 1 - 0.9$

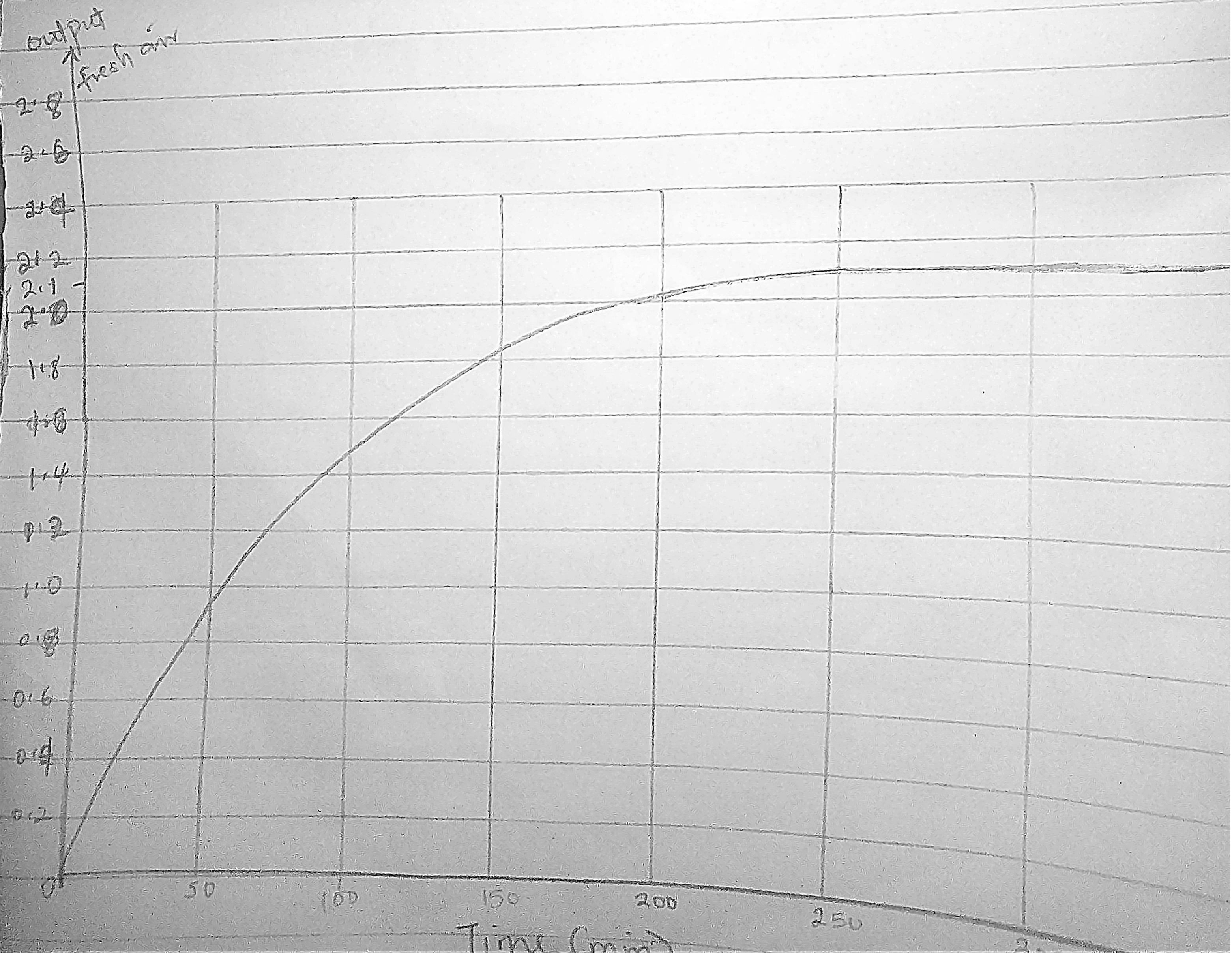
$e^{-0.03t} = 0.1$

$-0.03t = \ln 0.1$

$t = \frac{\ln(0.1)}{-0.03} = 76.75 mins.$

Command window

```
clear
clc
close all
t = 0:5:360
y = 20000*(1-exp(-0.03*t))
yn = subs(y)
plot(t, yn)
xlabel('Time(min)')
ylabel('Flowrate of fresh air')
grid on
grid minor
axis tight
```



(d) ~~So~~ The steady state value is $20000 ft^3$ at 215min of the exponential ~~approac~~. approach.

(e) The functions shows an exponential growth to the limit of $20000 ft^3$. as y increases with time, The steady state value is $20000 ft^3$ at 215 which means after the 6hours there was no fresh air entering or leaving the system.