Chioneke Okwudili
Chemical Engineering
17/Eng01/006

Assignment

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 be circulating fans, is exhausted at a rate of 600 ft^3/min. 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

Answer

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

$\frac{dy}{dt}$ = Air Inflow rate − fresh air outflow rate

Air Inflow ~~rate~~ → 600 ft^3/min

fresh air outflow → R/B: the amount flowing one of the room is a function of the amount in the room

$\frac{600}{20,000} = 0.03mm$

i.e. 0.03 of $y(t)$ is the outflow $= 0.03y\,ft^3/L$

Now

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

$= -0.03y + 600$

$= -0.03(y - 200,000)$

Thus the equation is separate and can be solved

$\frac{dy}{(y-20,000)} = -0.03dt$

Integrate both sides

$ln(y - 200000) = -0.03t + c$

$y - 200000 = e^{-0.03t} + e^{c}$

$y - 200000$ $C = e^{0}$ = Initial Condition $y - 20000 = e^{-0.03t}$ — (1)

If $t = 0$, $y(t) = 0$ since the room contained no fresh air initially

$y = 200,000 \cdot ce^{-0.03t}$

$0 - 20000 = C$

∴ $(E)\,e = -20000$ —— (2)

Put a in equation 2

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

$y = 20000(1 - e^{-0.03t})$ ——— (xx)

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

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

$90\% = \frac{90}{100}$

$= 0.9$

$y = 0.9$ of 20000 be 90% of air in the room

$= 0.9 \times 20000$

$= 18000 ft^3$

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

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

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

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

$e^{-0.03t} = 0.1$

$-0.03t = \ln(0.1)$

$e = \frac{\ln(0.1)}{-0.03}$

$t = \frac{-2303}{-0.03}$

$= 76.77$

$= 77 mins$

$\therefore$ The air in the room will be 90% fresh at 77minUte

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 sheep of 5min

NB: t = 6hrs = 6 x 60 = 360minutes

Codes

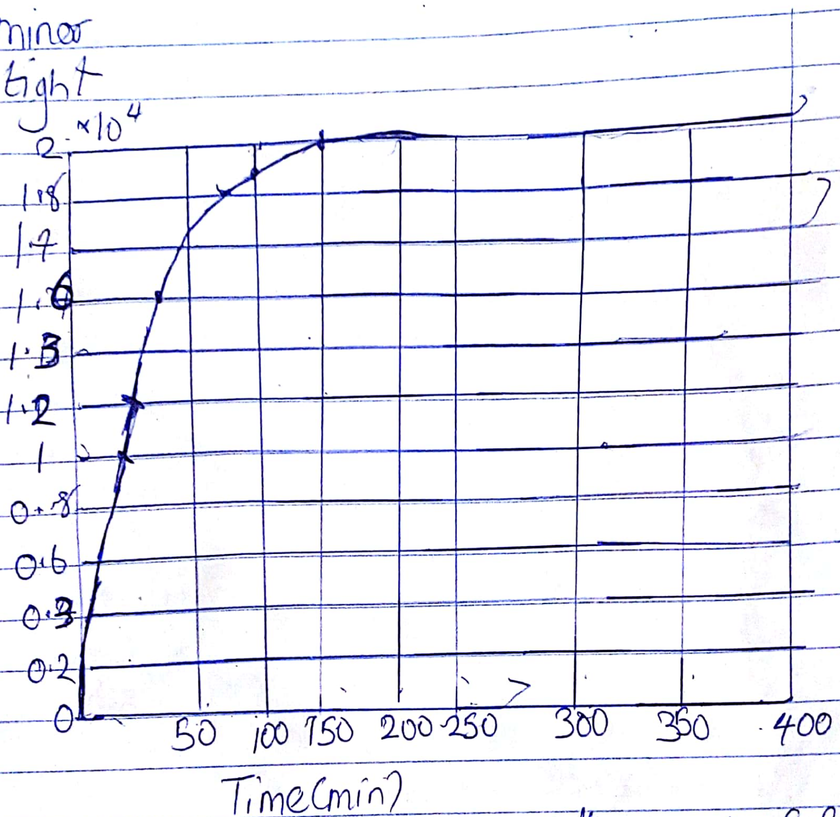
Command window

Clear all

Close all

```
Sym Y,t,k
Y=20000 (1-exp(-0.03*t))
t=0:5:360
Yn=subs(Y)
Plot(t,yn)
xlabel('Time (min)')
ylabel('FLOWRATE of FRESHAIR ft^3/min')
grid on
grid minor
axis tight
```

Output



d) Determine the Steady-State Value of the amount of fresh air in the room

Answer

The steady-state value is 20000ft³ at 25mins of exponential approach

e) Comment on answer in (d)

The function shows an exponential approach to the limit of 2000ft³ as q increases with time. Also when the steady-state value approach 20000ft³ at 45mins and continues till 360minutes (hours) The model discussed becomes more relative in pneumatic technology, although maybe difficult because mixing may be imperfect