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AtENG05 1002
Mechatronics Engineering

1. A … that of fresh air flows into a room containing 20000ft³ of air. The mixture which is made practically uniform by circulating fans, is exhausted at the rate 600ft³/min. If the room contains no fresh initially
a) develop a model for the amount of fresh air in the room at any time

Answer.

Let y(t) be the amount of air at any time t in ft³ in the room

$\frac{dy}{dt}$ = fresh air inflow rate - fresh air …

Fresh air inflow = 600ft³/min

Fresh air outflow. Note the amount flowing out of the room is a fraction of the amount in the room

$\frac{600}{20,000} = 0.03 \text{min}$

i.e 0.03 of y(t) is the outflow = 0.03y ft³/min

Now

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

$= -0.03y + 600$

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

This equation can be separated & integrated

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

find the integral of both side

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

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

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

Assum $C = e^{c}$ = initial equation

$y - 20000 = e^{-0.03t}\,C$

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

put $y = 0$, $t = 0$ in equ (1)

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

$0 - 20000 = e^{0} \cdot c$

$0 - 20000 = 1(c)$

$c = -20000$ ..... (2)

put eqn (2) in eqn (1)

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

$y = 20000(1 - e^{-0.03t})$ ..... (3)

Equation 3 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 be fresh $90\% = \frac{90}{100} = 0.9$

$y = 0.9 \times 20000$ is 90% of air in the room.

$= 18000 ft^3$

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

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

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

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

$e^{-0.03t} = 0.1$

$t = \frac{\ln 0.1}{-0.03}$

$= \frac{-2.303}{-0.03}$

$= 76.77 min$

$= 77 mins$

c) Write the m file of matlab, plot the ~~dynamic~~ dynamic response of the amount of fresh air in the room for $t = 0$ to $t = 6 hrs$ using a step of 5 min

Note $t = 6 hrs$

$= 6 \times 60$

$= 360 mins$

Solution

Command window

clear all

cle

Close all

Syms y, t

y = 20000 * (1 − exp(−0.03*t))

t = 0:5

yn = subs(y)

plot(t, yn)

xlabel('Time (min)')

ylabel('flowrate of fresh air (ft^3/min')

Grid on

Grid minor

Axis tight

out put

i) Determine the steady state value of the amount of fresh air in the room

A: The steady state value is 20000 FT^3 at 215min (3hr and 35 min) at exponential approach.

e) Comment on answer

The graphs above shows an exponential approach to the limit of 20000ft^3 as y increases with time. Also when the steady state value approaches 20000ft^3 at 215min and continues for 300min (6hrs). The model becomes more realistic in pharmacie technology, although maybe difficult because mixing may be imperfect