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17/ENG02/012
Computer Engineering

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

$\frac{dy}{dt}$ → fresh air inflow rate − outflow rate

fresh air inflow = 600 ft^3/min

" " outflow − N.B: The amount flowing out of the room is a function of the amount in the room.

$\therefore \frac{600}{20000} = 0.03 min$

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

$= -0.03y + 600$

$= -0.03(y - 20000)$

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

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

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

Recall $C = e^C$ = initial equation

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

At $t = 0$, $y(t) = 0$

$y - 20000 = Ce^{-0.03(0)}$

$0 - 20000 = C$

$C = -20000$

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

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

model of fresh air in the room

5. time which 90% of the air will be fresh

$$90\% = \frac{90}{100} = 0.9$$

$$y = 0.9 \text{ of } 20000$$

$$= 0.9 \times 20000$$

$$= 18000 \text{ ft}^3$$

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

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

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

$$e^{-0.03t} = 0.1$$

$$-0.03t = \ln 0.1$$

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

$$t = 76.87$$

$$t \approx 77 \text{ mins}$$

(c) Use matlab plot the dynamic response

$$t = 6 \text{ hrs}$$

$$= 6 \times 60$$

$$= 360 \text{ mins}$$

Solution

Commandwindow

Clear all

Clc

Close all

Syms y, t, k

$y = 20000 * (1 - \text{Exp}(-0.03*t))$

$t = 0:5:360$

$y = \text{subs}(y)$

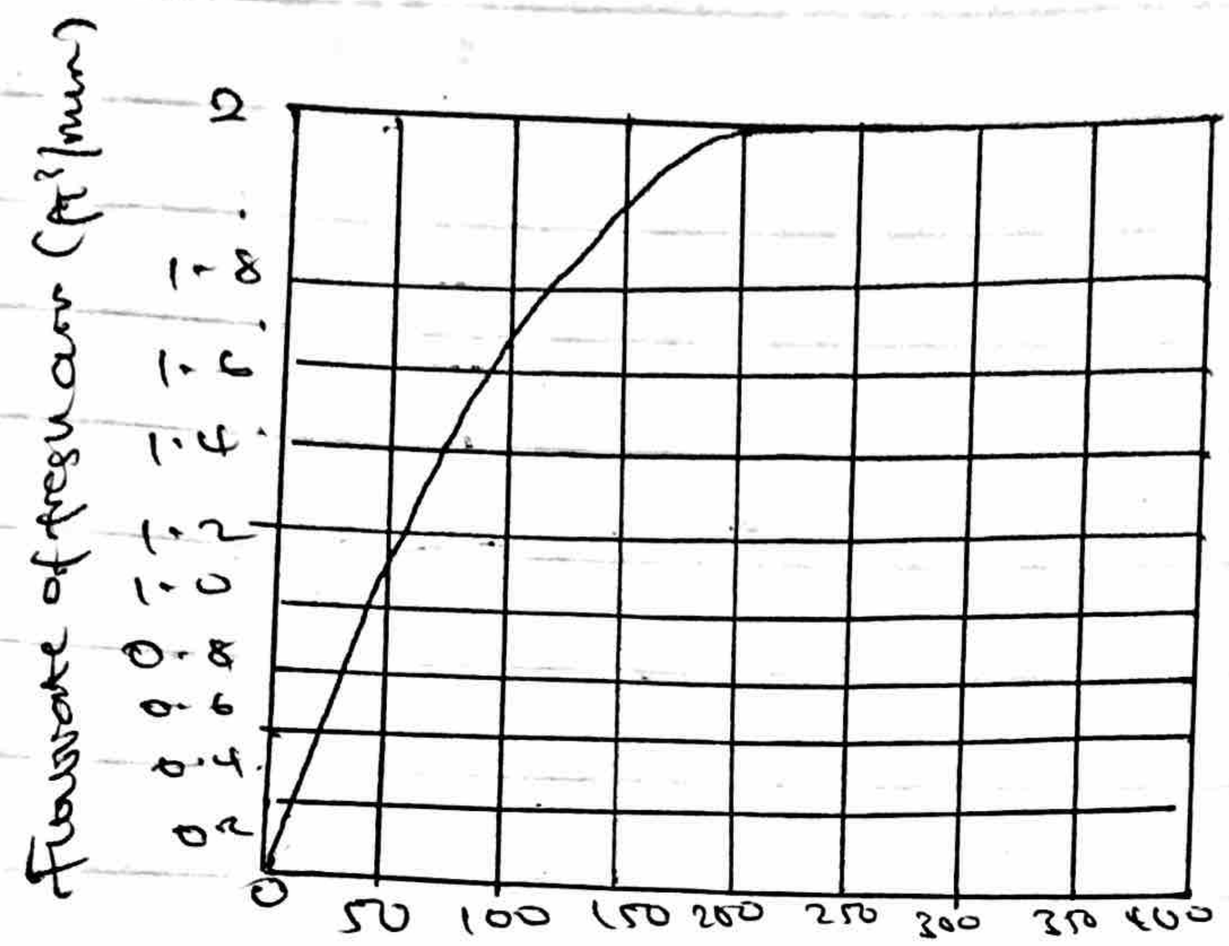
Xlabel ('Time (min)')

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

Grid on

Grid minor

Axis right



d. A: The steady-state value is 20000ft^3 at 215mins

c. The function shows an exponential approach to the limit of 20000ft^3 as y increases with time. Also when the steady flow state value approaches 20000ft^3 at 215mins and moves for 360mins to 6 hours. The model becomes more realistic pneumatic technology wise, although it may be difficult because mixing may be imperfect