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Civil Engineering
Eng 282

It is discovered that 600ft³/min of fresher flows into a room containing 20,000ft of air. The mixture which is made practically Uniform by circulating fans, is exhausted at the rate of 600ft³/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.

Solution

Let $y(t)$ be the amount of air at any time t in ft³ in the $\frac{dy}{dt}$ → fresh air inflow rate - fresh air outflow rate at

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

$$\therefore \frac{600}{20000} = 0.03 \text{cmm}$$

Now,

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

$$= -0.03y + 600$$

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

This equation can be suspended and integrated;

$$\frac{dy}{(y-2000)} = -0.03dt$$

find the integral of both sides

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

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

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

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

$$\therefore y - 20000 = e^{-0.03t} \cdot C \quad \text{——— (1)}$$

At $t = 0$, $y(t) = 0$ since the room contained no fresh o
Initially

Put $y = 0$, $t = 0$ in eqn 1

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

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

$$0 - 20000 = 1(C)$$

$$C = -20000 \quad \text{——— (2)}$$

put eqn (2) in eqn (1)

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

$$y = 20000(1 - e^{-0.03t}) \quad \text{——— (3)}$$

Equation (3) above is the model for the amount of fresh air in the room

(5) Calculate the time at which 90% of the air in ~~them~~ the room will become

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

$\therefore 0.9 \times 20000$; i.e 90% of air in the room

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

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

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

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

$$-0.03t = \ln(0.1)$$

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

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

(6) With the aid of matlab, plot the dynamic response of the amount of fresh air in the room for $t = 0$ to $t =$ this using a step of 5min

Note: $t = 6$ hrs

$= 6 \times 60$

$= 360$ mins.

solution

```
Command Window
clear all
clc
close all
Syms y, t
y = 20000.* (1 - exp(-0.03*t))
t = 0:5:360
yn = subs(y)
plot(t, yn)
xlabel('Time(mm)')
ylabel('flowrate of fresh air(ft^3/mm)')
Grid on
Grid minor
Axis tight
```

Output

(d) i) Determine the steady-state value of the amount of fresh air in the room.

Answer: The steady-state value is 20000 ft^3/mins. 215 mins (3hrs and 35mins) at exponential approach

(e) comment: The functions above shows an exponential equation to the limit of $20,000\ ft^3$ as y increases with time. Also when the steady state values approaches $20000\ ft^3$ at 215 minutes and continues for 300 minus (6hrs) the model discussed becomes more relative in pneumatic technology, although managed maybe difficult because mixing may be imperfect.