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Matric Number: 17/ENG01/022.

It is discovered that 600ft³/min of fresh air flows into a room containing 2000ft³ of air. The mixture which is made practically uniform by circulating fans, is exhausted at a rate of 600 cubic feet per minute (cfm). 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 at any time 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 and

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

Solution

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

Fresh air inflow → 600ft³/min.

Fresh air outflow → Remember the amount flowing out of the room is a function of the amount in the room.

$$\frac{600}{20000} = 0.03 mm'$$

∴ 0.03mm is the fresh air outflow.

$$dy/dx = 600 - 0.03y$$

$$= -0.03y + 600$$

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

∴ The equation can therefore be solved:

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

Integrating both sides:

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

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

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

Recall that $C = e^{0}$

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

$0 = 20000 - C$

$C = -20000$

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

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

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

(b) $90\% = \frac{90}{100} = 0.9$.

$y = 0.9$ of 20000

0.9×20000

$= 18000ft^3$

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

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

$e^{-0.03t} = 0.1$

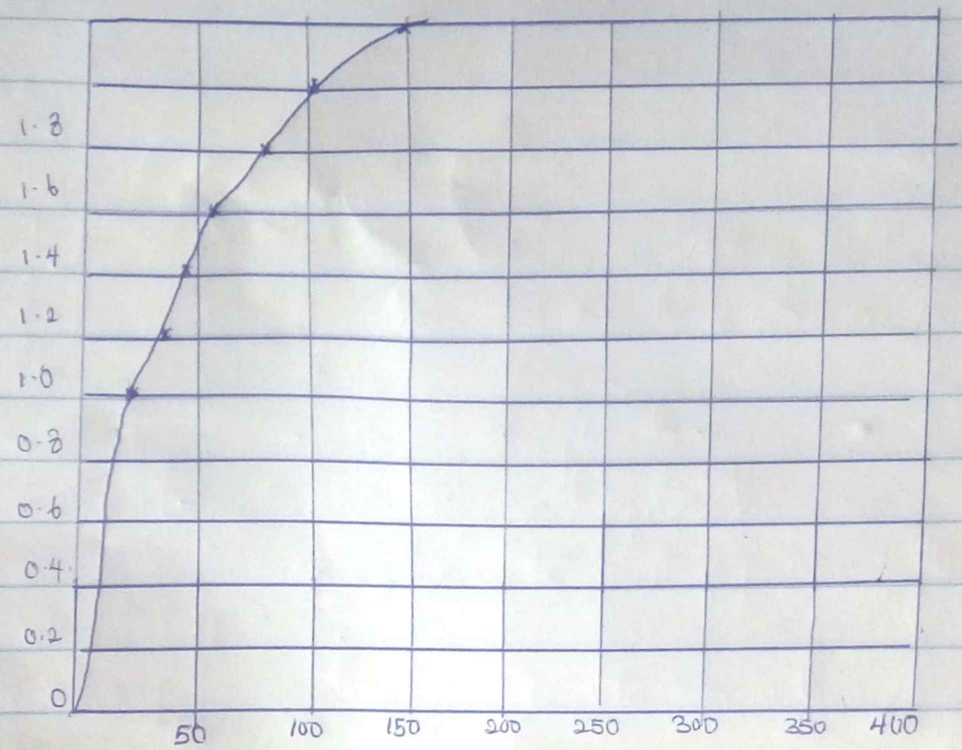
$-0.03t = \ln(0.1)$

$t = 77 mins$.

The air in the room will be 90% fresh at 77minutes

(c) Commandwindow

```
Clear all
clc
Close all
Syms y, k, t
y= 20000*(1-exp(-0.03*t))
t= 0:5:360
Yn= subs(y)
Plot(t, Yn)
xlabel('Time(mins)')
ylabel('flowrate of fresh air (ft^3/min)')
grid on
grid minor
```



(d) The steady value is 2000ft^3/min at 215mins of exponential approach.

(e) It shows that the limit of 20000ft^3 of y increases with time. Also when the steady state value approaches 20000ft^3 at 215mins and continues till 360minutes (1hour). The model discusses becomes more relastic in pneumatic technology although maybe because mixing may be imperfect.