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CHEMICAL ENGINEERING

17/EN901/031

Solution.

Let  $y(t)$  be the amount of air time  $t$  in ( $\text{ft}^3$ ) in the room

fresh air inflow  $\rightarrow 60 \text{ ft}^3/\text{min}$ .

fresh air outflow  $\rightarrow$  Remember the amount flowing out of the room is a function of the amount in the room.

$$\frac{60 \cancel{\text{ft}^3}}{200 \cancel{\text{ft}^3}} = 0.03 \text{ min}$$

$\therefore 0.03 \text{ min}$  is the fresh air outflow.

$$\begin{aligned} \frac{dy}{dx} &= 600 - 0.03y \\ &= 0.03y + 600 \\ &= -0.03(y - 20000) \end{aligned}$$

$\therefore$  The equation can therefore be solved

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

Integrating both sides.

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

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

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

Recall that  $C = e^0$

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

$$0 - 20000 = C$$

$$C = -20000$$

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

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

$\therefore$  The equation above is the model for the amount of fresh air in the room.

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

$$b) \quad 90\% = \frac{qd}{100} = 0.9$$

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

$$0.9 \times 20000 \\ = 18000 \text{ ft}^3$$

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

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

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

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

$$t = 77 \text{ mins,}$$

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

a) Command window

clear all

close all

syms y, k, t

$$y = 2000 \cdot 0.9 \cdot (1 - \exp(-0.03 \cdot t))$$

t = 0:s:360

Yn = subs(y)

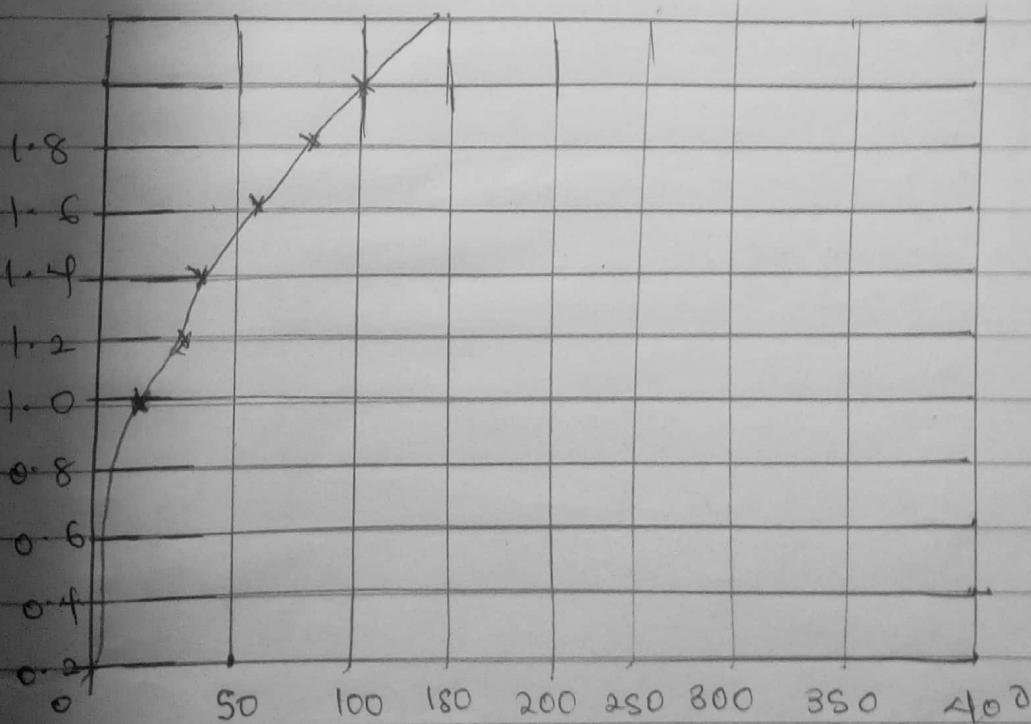
plot(t, Yn)

xlabel('Time (mins)')

ylabel('Flowrate of fresh air (ft<sup>3</sup>/min)')

grid on

grid minor



d) The steady value is 2000 ft<sup>3</sup>/min at 215 mins of exponential approach

e) It shows that the limit of 2000 ft<sup>3</sup> of y increases with time. Also when the steady state value approaches 2000 ft<sup>3</sup> at 215 mins and continues till 360 minutes (1 hour). The model discussed becomes more elastic in pneumatic technology although maybe because mixing may be imperfect.