ENG 282 ASSIGNMENT

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Solution

Balance Law

Rate of accumulation = (Rate of Inflow - Rate of outflow) of any material

Let the amount of the material be y

$$\frac{dy}{dt} = y_{in} - y_{out}$$

Rate of Inflow, $y_{in} = 600 ft^3 min^{-1}$

Rate of outflow, y_{out} = Rate of fresh air inflow of the material / volume of air mixture in the room $\times y$

$$y_{out} = \frac{600}{20,000} \times y = 0.03y$$

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

$$\frac{dy}{dt} = -0.03(y - 20,000)$$

$$\frac{dy}{y - 20,000} = -0.03dt$$

$$\int \frac{dy}{(y - 20,000)} = -\int 0.03dt$$

$$\ln(y - 20,000) = -0.03t + C$$

$$y - 20,000 = e^{-0.03t + C}$$

$$y - 20,000 = e^{-0.03t} e^{C}, \text{ let } e^{C} = y_0$$

$$y - 20,000 = y_0 e^{-0.03t}$$

$$y = 20,000 + y_0 e^{-0.03t} \text{ [General solution]}$$

When $t = 0$

$$y = 0$$

$$0 = 20,000 + y_0$$

$$y_0 = -20,000$$

$$y = 20,000 - 20,000 e^{-0.03t} \text{ [Particular solution]}$$

b when $y = 90\%$

$$\frac{90}{100} = 20{,}000 - 20{,}000e^{-0.03t}$$

$$0.9 = 20{,}000 - 20{,}000e^{-0.03t}$$

$$0.9 - 20{,}000 = -20{,}000e^{-0.03t}$$

$$-19999.1 = -20{,}000e^{-0.03t}$$

$$e^{-0.03t} = 0.9999$$

$$-0.03t = \ln(0.9999)$$

$$t = 1.5 \times 10^{-3} \text{ min}$$

c. The steady-state value of the amount of fresh air in the room is $20{,}000 ft^3$

d. From the result obtained in (c) it can be said that the amount of fresh air increase with time initially until it reaches $20{,}000 ft^3$ and then the amount of fresh air remains constant with increase in time in the room.