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Dept :- Mechanical Eng

1) It is discovered that $600ft^3/min$ of fresh air flows into a room containing $20000ft^3$ 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.

Soln

a.) Develop a model for the amount of fresh air at any time

x) Let y represent fresh air.

x) Rate of accumulation = rate of inflow - rate of outflow.

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

rate of inflow = $600ft^3/min$

rate of outflow = $\frac{600}{20000} \times y = 0.03y$

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

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

$$\ln[y - 20000] = -0.03t + C$$

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

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

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

If the room contained no fresh air

$y = 0, \quad t = 0$

$0 = 20000 + y_o$

$y_o = -20000$

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

$$y = 20000\left[1 - e^{-0.03t}\right]$$

This model is for the amount of air at any time, t

b) Calculate the time which 90% of the air in the room will have become fresh.

Soln

Room contains 20000 ft^3 of air

90% of 20000 = 18000 ft^3/min

=> from the model, $y = 20000\left[1 - e^{-0.03t}\right]$

$18000 = 20000\left[1 - e^{-0.03t}\right]$

$e^{-0.03t} = -\left[\frac{18000}{20000} - 1\right]$

$e^{-0.03t} = 0.1$

$-0.03t = \ln[0.1]$

$-0.03t = -2.303$

$t = \frac{2.303}{0.03} = 76.77\,min$

d) From the dynamic response plotted, the steady state value of the amount of fresh air in the room in 20000 ft^3 of air.

e) It was noticed that the value of amount of fresh air steadily increase until it get to 20000 ft^3 of air. Therefore despite the increase in time, the amount of fresh air remained 20000 ft^3 giving the steady-state value. In conclusion, 20000 ft^3 of air is the maximum air for the room.

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