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MECHANICAL ENGINEERING
ENG 282

1. It is discovered that 600ft³/min of fresh air flows into a room containing 20,000 ft³ of air. The mixture, which is made pratically uniform by circulating fans, is exhausted at a rate of 600 cubic feet per minute [Cfm]. If the room contains no fresh air initially.

Solu

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

*Let y represent fresh air

*Rate of Accumulation = rate of Inflow − rate of outflow

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

rate of inflow = 600 ft³/min

rate of outflow = $\frac{600}{20,000} \times y = 0.03y$

$$dy/dt = -0.03(y - 2000)$$

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

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

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

$$y - 20000 = y_0 e^{-0.03t}$$

$$y = 20000 + y_0 e^{-0.03t}$$

If the room Contained no fresh air

$y = 0, \quad t = 0$

$$0 = 20000 + y_0$$

$$y_0 = -20000$$

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

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

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

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

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

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

$$-0.03t = \ln[0.1]$$

$$-0.03t = -2.303$$

$$t = \frac{2.303}{0.03} = 76.77 \text{ min.}$$

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 ~~time~~ the value of amount of fresh air steadily increase until it get to 20000ft^3 of air. Therefore despite the increase in time the amount of fresh air remained 20000ft^3 giving the steady – state value. In conclusion, 20000ft^3 of air is the maximum air for the room