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16/ENG04/043

Electrical Electronic E
ENG 282.

1.) It is discovered that 600 ft^3/min of fresh air flows into a room containing 20,000 ft^3 of air. The mixture which is made practically uniform by circulating fans, is exhausted at a rate of 600 cubic feet per minute (ft^3/m). If the room contains no fresh air initially, develop a model for amount of fresh air

Solution

Let y = fresh air

but rate of accumulation = rate of inflow − rate of outflow

$$\frac{dy}{dt}$$

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

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

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

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

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

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

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

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

a) $$y = 20,000 + y_0 \cdot e^{-0.03t}$$

b) If the room contain no fresh air

$y = 0 \quad t = 0$

$0 = 20,000 + y_0$

$y_0 = -20,000$

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

$$y = 20,000(1 - e^{0.03t})$$

The equation for y is the model for amount of air at any time t.

c.) Calculate the time when 90% of the air in the room will have become fresh

Solution.

room contains $20,000 ft^3$ of air

90% of 20,000

$= \frac{90}{100} \times 20,000 = 18,000 ft^3/min$

from the equation of the model

$y = 20,000(1 - e^{-0.03t})$

$= 18,000 = 20,000(1 - e^{-0.03t})$

$1 - e^{-0.03t} = \frac{18000}{20000}$

$e^{-0.03t} = 1 - \frac{18}{20}$

$e^{-0.03t} = 1 - \frac{9}{10} = 1 - 0.9$

$e^{-0.03t} = 0.1$

$-0.03t = \ln(0.1)$

$-0.03t = -2.303$

$t = \frac{2.303}{0.03}$

$= 76.77 min$

dynamic response

d.) from the graph plotted, the steady state value is $20,000 ft^3$ of air

e.) It was noticed that the value of amount of fresh air steadily increases until it reaches approximately $20,000 ft^3$ of air. Therefore, despite the increase in time, the amount of fresh air remained $20,000 ft^3$ giving the steady state. In conclusion the maximum air is $20,000 ft^3$ for the room.