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16/ENG01/018
CHEMICAL ENGINEERING.
ENG282 ENGINEERING MATHS.

1 Initial air = 20,000 ft^3.
Input of air = 600 ft^3/min.
in flow rate = 600 cfm.
Balance Law ⇒ Rate of accumulation in the system = rate of inflow - rate of outflow.

Let the amount of air at a time (t) = y(t).
$\frac{dy}{dt}$ = amount of material of y.

rate of flow = y'
$\frac{dy}{dt} = y'in - y'out$.

The out flow rate = $\frac{600}{20,000} = 0.03$.

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

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

$dy/dt = -0.03(y - 20,000)$
$\frac{dy}{(y-20000)} = -0.03dt$.

$\int \frac{1}{(y-20000)} = \int -0.03dt$

$\ln(y - 20,000) = -0.03t$
$y - 20000 = e^{-0.03t + C}$
$y - 20000 = e^{-0.03t} \cdot e^C$.
Let $e^C = y_0$.
$y - 20000 = y_0 e^{-0.03t}$.
$y = 20,00 + y_0 e^{-0.03t}$.

Calculating for y_0, if $t=0$.

$0 = 20000 + y_0 e^{-0.03(0)}$

$0 = 20,000 + y_0$

$y_0 = -20000$

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

b) Time taken for which 90% of air in room will become fresh Initial air = 20,000.

$\frac{90}{100} \times 20,000 = 18,000$

$18000 = 20,000 - 20000 e^{-0.03t}$.

$18000 - 20000 = -20000 e^{-0.03t}$.

$-2000 = -20000 e^{-0.03t}$.

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

$\ln 0.1 = 0.03t$.

$-2.30 = -0.03t$.

$76.6 = t$

$t = 76.6 \text{ min}$.

$t = 77 \text{ min}$.

(c) It was observed that the difference in the values of y was not much, on increase in time (t), led to an increase in y. When the graph was plotted, at a certain point there was no progression which is a steady state.

(d) The steady state value is 20,000.