BY: S. VISHAL
CH18B020

CH3030 TUTORIAL-10

(1)

$T_{interface} = T_{wet\ bulb} \Rightarrow T_{wet\ bulb} = 60°C$

$T_{air} = T_{dry\ bulb} \Rightarrow T_{dry\ bulb} = 160°C$

Using the dry bulb and wet bulb temperatures, we obtain the following from psychrometric charts:

- RH = 2.31%.
- Humidity ratio = 0.10188 kg/kg.
- Specific volume = 1.426 m^3/kg dry air.

$\Rightarrow$ Specific volume (wet-basis) = $\dfrac{1.426}{1+0.102}$ kg/kg air

$$G = u\rho = 3 \times \frac{1.426}{1+0.102} \ast$$

$$\Rightarrow G = 8343.245 \ kg/hm^2$$

From Seader Table 18-1, we obtain

$$h = 0.0204\, G^{0.8}.$$

[NOTE: This correlation is valid for only upto 150°C But due to lack of better options, and closeness of T (~10°C difference) I chose this]

$$\Rightarrow h = 0.0204(8343.245)^{0.8}$$

$$\Rightarrow h = 27.97 \ kW/m^2K$$

From steam tables,

$$\Delta H_{vap.} (T = 60°C) = 2357.69 \text{ kJ/kg}$$

$$\text{mass of solid} = \rho_s \times \text{Volume} = 1500 \times 0.03 \times 1$$

$$= 45 \text{ kg.}$$

$$-\frac{dm}{dt} = NA = \frac{h(T_{dry} - T_{g\,wet})}{\Delta H_{vap}} \times A.$$

[Constant Rate]

where $A = 1m^2$ (SA of square tray)

$$\Rightarrow \frac{|\Delta m|}{A \times \frac{h(\Delta T)}{\Delta H_{vap}}} = t \Rightarrow t = \frac{m_s \times (1 - 0.5)}{A\, h\, \Delta T} \times \Delta H_{vap}.$$

Substituting all the values we get.

$$\boxed{t = 5.694 \text{ hours}}.$$

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(2) Since the moisture content in solid is given in terms of free moisture, we write critical & eqbm contents also in terms of free moisture

At eqbm, free moisture = 0 (definition)

~~At~~ critical moisture content = 12%.

Removing the eqbm (bound) part,

critical moisture = 12% − 5%

= 7% free moisture content

Lower limits (10% & 8%) are both above critical moisture limit

$\Rightarrow$ Both the cases come under constant ~~rate~~ rate regime

As derived in the previous problem, in the constant rate regime we have,

$$t = \frac{m_s(X_i - X_f)}{A N}$$

~~case~~ 40 - 10% in 6 hours,

$$\Rightarrow \frac{NA}{m_s} = \frac{30}{6} = 5 \text{ hour}^{-1}$$

Time required to reach 8% from 45% free moisture,

$$t = \frac{m_s}{NA} \times (45 - 8) = \frac{37}{5}$$

$$\Rightarrow \boxed{t = 7.4 \text{ hours.}}$$

NOTE: We have assumed $\frac{NA}{m_s}$ to be same in both the cases because the material (A & m_s) and the conditions (which determine N) are given to be the same in both cases.