THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Mass Transfer-I

Drying

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Example

A batch of the solid, for which the following table of data applies, is to be dried from 25 to 6 percent moisture under conditions identical to those for which the data were tabulated. The initial weight of the wet solid is 350 kg, and the drying surface is 1 m^2/8 kg dry weight. Determine the time for drying.

$X \times 100, \frac{\text{kg moisture}}{\text{kg dry solid}}$	$N \times 100, \frac{\text{kg moisture evaporated}}{\text{hr} \cdot \text{m}^2}$
35	30
25	30
20	30
18	26.6
16	23.9
14	20.8
12	18
10	15
9	9.7
8	7
7	4.3
6.4	2.5

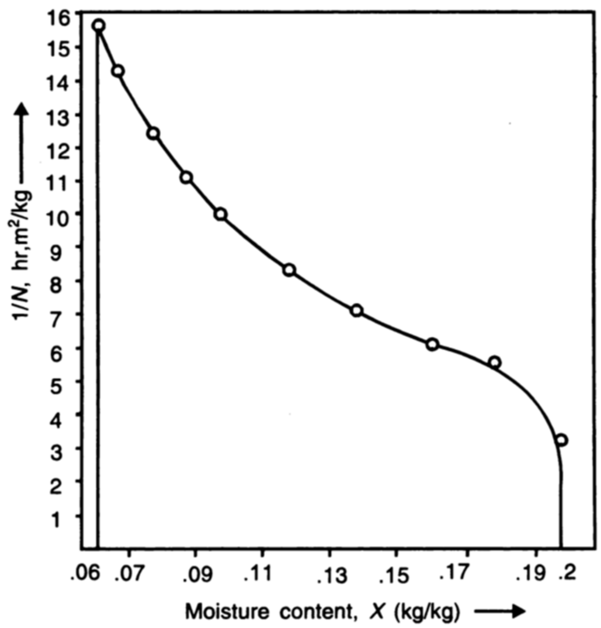


Fig. 6.18 Example 2 $1/N$ vs X for falling rate period.

Solution.

$$X_1 = \frac{0.25}{(1 - 0.25)} = 0.333, \qquad X_2 = \frac{0.06}{(1 - 0.06)} = 0.0638,$$

Initial weight of wet solid = 350 kg

Initial moisture content = 0.333 kg moisture/kg dry solid

So, total moisture present in wet solid (initially) = 350×0.25 = 87.5 kg moisture

Weight of dry solid, L_S = 262.5 kg

$$A = \frac{262.5}{8} = 32.8125 \text{ m}^2, \qquad \text{or } \frac{L_S}{A} = 8 \text{ kg/m}^2$$

$$X_{Cr} = 0.20, \qquad N_C = 0.3 \text{ kg/m}^2\text{hr}$$

So for constant rate period, drying time is

$$t_I = \frac{L_S}{AN_C}[X_1 - X_{Cr}] = \left[\frac{262.5}{(32.8125 \times 0.3)}\right][0.333 - 0.2] = 3.55 \text{ hr.}$$

For falling rate period, we are finding drying time graphically,

X	0.2	0.180	0.16	0.14	0.120	0.100	0.090	0.080	0.07	0.064
$1/N$	3.33	5.56	6.25	7.14	8.32	10.00	11.11	12.5	14.29	15.625

Area = 1.116,

$\therefore$ Time = Area under the curve $\times \dfrac{L_S}{A} = 1.116 \times \dfrac{L_S}{A} = 1.116 \times 8 = 8.928$ hr.

$\therefore$ Total time = 8.928 + 3.55 = 12.478 hr. **Ans.**

Example

A wet slab of material weighing 5 kg originally contains 50 percent moisture on wet basis. The slab is 1 m × 0.6 m × 7.5 cm thick. The equilibrium moisture is 5 per cent on wet basis. When in contact with air, the drying rate is given in the table below. Drying takes place from one face only.

(i) Plot the drying rate curve and find the critical moisture content.

Wet slab wt, kg	5.0	4.0	3.6	3.5	3.4	3.06	2.85
Drying rate, kg/(hr)(m^2)	5.0	5.0	4.5	4.0	3.5	2.00	1.00
X, Dry basis	1.00	0.6	0.44	0.4	0.36	0.224	0.14

(ii) How long will it take to dry the wet slab to 15 percent moisture on wet basis?

Solution. Weight of wet solid = 5 kg

Moisture content = 0.50 moisture/kg wet solid

$$= \frac{0.5}{[(0.5 \text{ moisture}) + (0.5 \text{ dry solid})]} = \frac{0.5}{(1 - 0.5)}$$

$\therefore X_1 = 1 =$ moisture/dry solid

For 5 kg wet solid, moisture = 5 × 0.5 = 2.5 kg

Weight of dry solid = 5 – 2.5 = 2.5 kg

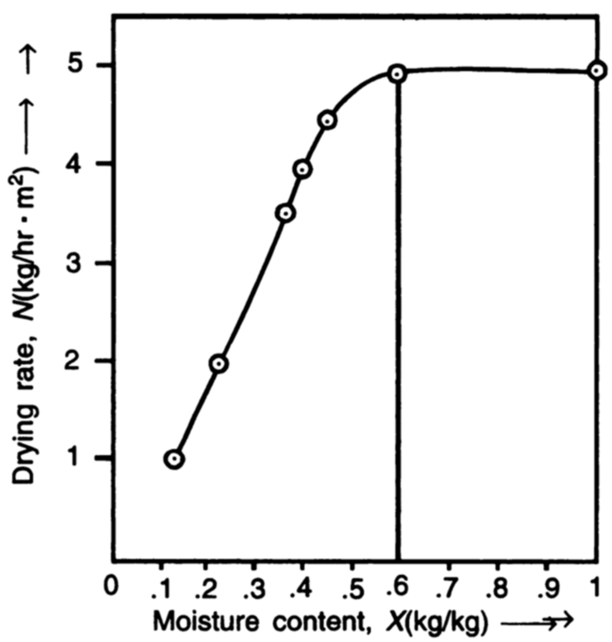


Fig. 6.19(a) Example 3 Drying rate curve.

$$x^* = 0.05, \qquad X^* = \frac{0.05}{(1-0.05)} = 0.0526$$

$$\text{Moisture content in dry basis} = \frac{\text{weight of wet solid} - \text{weight of dry solid}}{\text{weight of dry solid}}$$

Ans.

(i) $X_{Cr} = 0.6$ kg moisture/kg dry solid.

(ii) From $X = 0.6$ to 0.44 the falling rate curve is non-linear and from $X = 0.44$ to 0.14, falling rate period is linear.

$$X_2 = \frac{0.15}{(1 - 0.15)} = 0.1765.$$

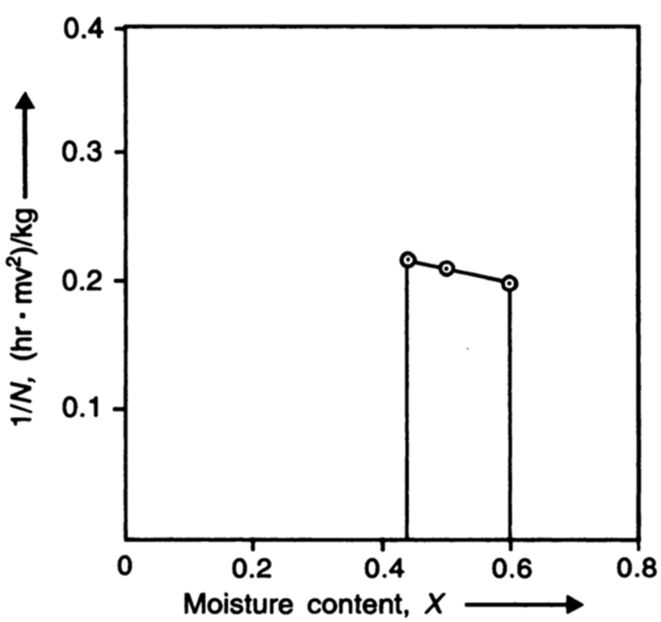


Fig. 6.19(b) Example 3 $1/N$ vs X.

So, we can find time for drying from 0.6 to 0.44 graphically and then for $X = 0.44$ to 0.1765, we can go in for analytical solution as the 'N' vs 'X' relation is linear.

Time taken for constant rate drying period (From $X = 1$ to $X = 0.6$)

$$t_I = \left[\frac{L_S}{AN_C}\right][X_1 - X_{Cr}] = \left[\frac{2.5}{(5 \times 0.6)}\right][1 - 0.6] = 0.333 \text{ hr}$$

(from $X = 0.44$ to 0.1765)

$$t_{II} = \frac{L_S}{AN_C} \times \left\{(X_{Cr} - X^*) \ln\left[\frac{(X_1 - X^*)}{(X_2' - X^*)}\right]\right\}$$

$$\left(X^* = \frac{0.05}{(1 - 0.05)} = 0.0526\right)$$

$$t_{II} = \left[\frac{2.5}{(5 \times 0.6)}\right] \times \left\{(0.6 - 0.0526) \times \ln\left[\frac{(0.44 - 0.0526)}{(0.176 - 0.0526)}\right]\right\}$$

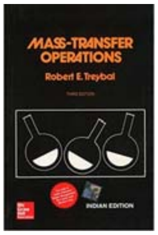
$= 0.522$ hr **Ans.**

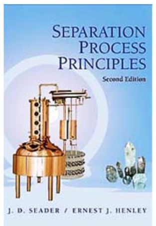
From graph, t_{III} (From $X = 0.6$ to $X = 0.44$) $= \dfrac{(0.0336 \times 2.5)}{0.6} = 0.14$ hr.

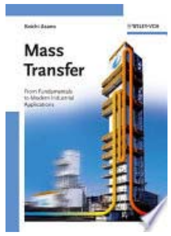
Total time $= t_I + t_{II} + t_{III} = 0.333 + 0.522 + 0.14 = 0.995$ hr or 59.58 min. **Ans.**

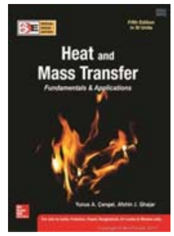
Dr. Avinash Chandra

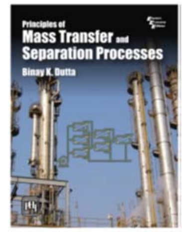
References

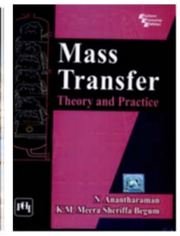












ETH

Mass Transfer

Theories for Mass Transfer Coefficients

Lecture 9, 15.11.2017, Dr. K. Wegner

- Lecture notes/ppt of Dr. Yahya Banat (**ybanat@qu.edu.qa**)

CHEMICAL ENGINEERING AND CHEMICAL PROCESS TECHNOLOGY – Vol. II - *Mass Transfer Operations: Absorption And Extraction* - José Coca, Salvador Ordóñez and Eva Díaz

MASS TRANSFER OPERATIONS: ABSORPTION AND EXTRACTION

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