Mass transfer correlations for packed towers

Correlations for k_x and k_y would need to be combined with further correlations for the interfacial area per volume a to estimate

$$H_x = \frac{L/S}{k_x a} \quad \text{and} \quad H_y = \frac{V/S}{k_y a}.$$

Note that a is not the surface area per volume of the dry packing, and depends on the flow conditions. (The wavy/ rippled/frothy surface of liquid running down the packing would be greater than that of the substrate it flows over; cf. the sentence "…the large effect of liquid rate on interfacial area" (p. 602); see also p. 600.)

Why not just develop correlations directly for the quantities you really want to know, namely H_x and H_y? Less work for Elroy $\Rightarrow$ Totally man!

The equations given below tend to be more convenient to use than the graphs presented in the textbook (Figures 18.21 and 18.22).

1. Correlation for H_x

H_x increases with the 0.2–0.4 power of G_x, and depends weakly on G_y. It is generally taken to scale with the square root of the solute's Schmidt number in the liquid, and depends on the type of packing used. Based on data for O_2 in water, it may be estimated using the following representative correlation equation

$$H_x = (0.9 \text{ ft}) \left[\frac{G_x/\mu}{(1500 \text{ lb}/(\text{ft}^2 \text{ h}) \ / \ (0.891 \text{ cP})} \right]^{0.3} \left(\frac{\text{Sc}}{381} \right)^{0.5} \frac{1}{f_p}$$

The factor f_p scales the equation appropriately for different packings. Note that the factor written as **lowercase** letter *f*
Is the one that must be used with this and other mass transfer correlations (listed in the rightmost column in Table 18.1).

2. Correlation for H_y

H_y increases with the 0.3–0.4 power of G_y and the negative 0.4–0.7 power of G_x. It is also taken to scale with the square root of the solute's Schmidt number in the gas, and depends on the type of packing used. Based on data for data for absorption of ammonia from air by water, it may be estimated using the following representative correlation equation.

$$H_y = (1.4 \text{ ft}) \left[\frac{G_y}{500 \text{ lb/(ft}^2\text{ h)}}\right]^{0.3} \left[\frac{1500 \text{ lb/(ft}^2\text{ h)}}{G_x}\right]^{0.4} \left(\frac{\text{Sc}}{0.66}\right)^{0.5} \frac{1}{f_p}$$

Here again the factor f_p scales the equation appropriately for different packings. Remember that the factor written as **lowercase** letter *f* is the one that must be used with this and other mass transfer correlations (listed in the rightmost column in Table 18.1).

3. General comments

Other textbooks give similar equations with slight variations on the constants and exponents. For example, Geankopolis (2003) gives equations that can be written in the form

$$H_x = (0.816\ \text{ft}) \left[\frac{G_x/\mu}{(1500\ \text{lb}/(\text{ft}^2\ \text{h})\ /\ (0.894\ \text{cP})} \right]^{0.3} \left(\frac{\text{Sc}}{372} \right)^{0.5} \frac{1}{f_p}$$

$$H_y = (1.35\ \text{ft}) \left[\frac{G_y}{500\ \text{lb}/(\text{ft}^2\ \text{h})} \right]^{0.35} \left[\frac{1500\ \text{lb}/(\text{ft}^2\ \text{h})}{G_x} \right]^{0.5} \left(\frac{\text{Sc}}{0.66} \right)^{0.5} \frac{1}{f_p}$$

The values of G_x and G_y used should be representative of the entire packed tower. Therefore it is appropriate to use the averages of the values at the top (“a” end) and bottom (“b” end) of the tower as follows.

$$G_x = \left[(G_x)_a + G_x)_b \right] /2$$

$$G_y = \left[(G_y)_a + G_y)_b \right] /2$$