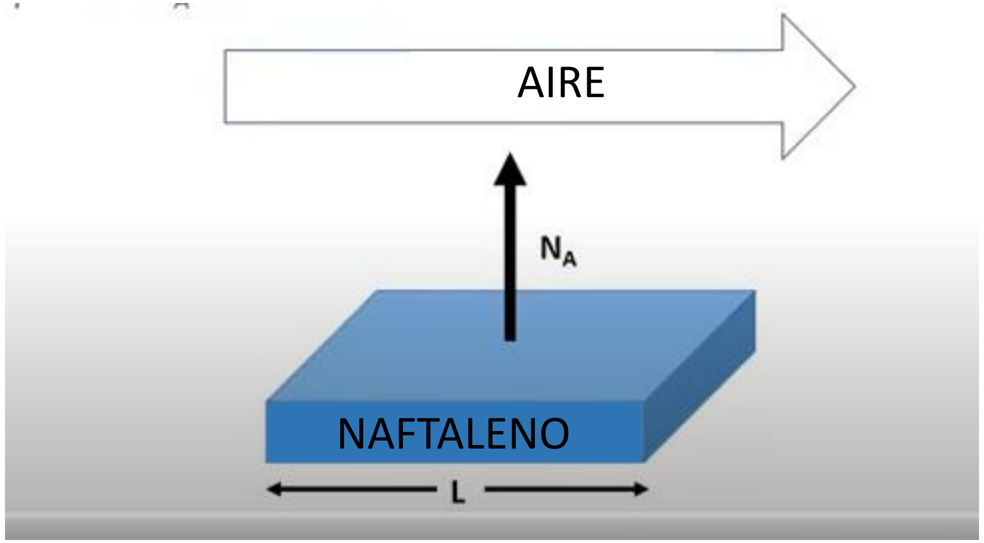
TRANSFERENCIA DE MASA SOBRE UNA PLANA

PROBLEMA 3: Una placa delgada de naftaleno sólido, con superficie de 1 m^2, se orienta paralela a una corriente de aire que fluye a 20 m/s. El aire está a 310 K y $1.013.10^5$ Pa. El naftaleno permanece a 290 K, a dicha temperatura, la difusividad del naftaleno en aire es $5.61.10^{-6}$ m^2/s y su presión de vapor de 26 Pa.

Determinar:

a) El valor del coeficiente de transferencia de masa en un punto a 0.3 m corriente abajo del extremo de referencia.

b) Los moles de naftaleno por hora que se pierden de la sección de la placa que esta entre 0.5 y 0.75 m corriente abajo del extremo de referencia.



water. By correlating the data in terms of dimensionless parameters, these empirical equations can be extended to other moving fluids and geometrically similar surfaces.

Flat Plate

Several investigators have measured the evaporation from a free liquid surface or sublimation from a flat, volatile solid surface into a controlled air stream. Mass-transfer coefficients obtained from these experiments compare favorably with the mass-transfer coefficients theoretically predicted for laminar and turbulent boundary layers. The appropriate correlations are

$$\mathrm{Sh}_L = \frac{k_c L}{D_{AB}} = 0.664\,\mathrm{Re}_L^{1/2}\,\mathrm{Sc}^{1/3} \qquad \text{(laminar) } \mathrm{Re}_L < 2 \times 10^5 \qquad (28\text{-}21)$$

$$\mathrm{Sh}_L = \frac{k_c L}{D_{AB}} = 0.0365\,\mathrm{Re}_L^{0.8}\,\mathrm{Sc}^{1/3} \qquad \text{(turbulent) } \mathrm{Re}_L > 2 \times 10^5 \qquad (28\text{-}26)$$

with Re_L defind as

$$\mathrm{Re}_L = \frac{\rho v_\infty L}{\mu}$$

where L is the characteristic length of the flat plate in the direction of flow. At a distance x from the leading edge of the flat plate, the exact solution to the laminar boundary layer problem resulting in the theoretical prediction for the local Sherwood number, given by

$$\mathrm{Sh}_x = \frac{k_c x}{D_{AB}} = 0.332\,\mathrm{Re}_x^{1/2}\,\mathrm{Sc}^{1/3} \qquad (28\text{-}20)$$

$$\mathrm{Sh}_x = 0.0292\,\mathrm{Re}_x^{4/5}\,\mathrm{Sc}^{1/3}$$

also agrees with experimental data, where the local Reynolds number, Re_x, is defined as

$$\mathrm{Re}_x = \frac{\rho v_\infty x}{\mu}$$

The above equations may also be expressed in terms of the *j*-factor by recalling

$$j_D = \frac{k_c}{v_\infty}\mathrm{Sc}^{2/3} = \frac{k_c L}{D_{AB}} \cdot \frac{\mu}{L v_\infty \rho} \cdot \frac{D_{AB}\rho}{\mu} \cdot \left(\frac{\mu}{\rho D_{AB}}\right)^{2/3} = \frac{\mathrm{Sh}_L}{\mathrm{Re}_L\,\mathrm{Sc}^{1/3}} \tag{30-1}$$

Upon rearranging equations (28-21) and (28-26) into the form of equation (30-1), we obtain

$$j_D = 0.664\,\mathrm{Re}_L^{-1/2} \quad \text{(laminar)}\ \mathrm{Re}_L < 2 \times 10^5 \tag{30-2}$$

and

$$j_D = 0.0365\,\mathrm{Re}_L^{-0.2} \quad \text{(turbulent)}\ \mathrm{Re}_L > 2 \times 10^5 \tag{30-3}$$

These equations may be used if the Schmidt number is in the range $0.6 < \mathrm{Sc} < 2500$. The *j*-factor for mass transfer is also equal to the *j*-factor for heat transfer in the Prandtl number range of $0.6 < \mathrm{Pr} < 100$ and is equal to $C_f/2$.

7.3E Transferencia de masa para el flujo fuera de superficies sólidas

1. Transferencia de masa de flujo paralelo a placas planas. La transferencia de masa o la vaporización de líquidos de una placa o superficie plana a una corriente, reviste gran interés en el secado de materiales inorgánicos y biológicos, en la evaporación de disolventes de pinturas, para las placas en túneles de viento y en los canales de flujo de equipos de proceso químico.

Cuando el fluido fluye sobre una placa con corriente libre en un espacio abierto, la capa límite no esta totalmente desarrollada. Para gases o la evaporación de líquidos a fase gaseosa en la región laminar de $N_{Re,\ L} = Lv\rho/\mu$ inferior a 15000, los datos pueden representarse con exactitud de ±25% por medio de la ecuación (S4)

$$J_D = 0.664\ N_{Re,\ L}^{-0.5} \tag{7.3-26}$$

Al escribir la ecuación (7.3-26) en términos del número de Sherwood N_{Sh},

$$\frac{k_c' L}{D_{AB}} = N_{Sh} = 0.664\ N_{Re,\ L}^{0.5}\ N_{Sc}^{1/3} \tag{7.3-27}$$

donde L es la longitud de la placa en el sentido de flujo. Además, $J_D = J_H = f/2$ en esta geometría. Para gases y $N_{Re,\ L}$ entre 15000 y 300000, los datos se representan con exactitud de ±30% por medio de $J_D = J_H = f/2$ como

$$J_D = 0.036\ N_{Re,\ L}^{-0.2} \tag{7.3-28}$$

Los datos experimentales para líquidos se correlacionan con exactitud de ±40% cuando $N_{Re,\ L}$ está entre 600-50000 (L2) por medio de

$$J_D = 0.99\ N_{Re,\ L}^{-0.5} \tag{7.3-29}$$

TRANSFERENCIA DE MASA SOBRE ESFERAS

$$\mathrm{Sh} = \frac{k_c D}{D_{AB}}$$

and

$$Re = \frac{\rho v_\infty D}{\mu}$$

where D is the diameter of the sphere, D_{AB} is the diffusion coefficient of the transferring species A in gaseous or liquid species B, v_∞ is the bulk fluid velocity flowing over the sphere, and ρ and μ are the density and viscosity of the fluid mixture, respectively, usually approximated as species B at dilute concentration of A. Mass-transfer correlations for single spheres consider the sum of the molecular diffusion and forced convection contributions

$$\mathrm{Sh} = \mathrm{Sh}_o + C\,\mathrm{Re}^m\,\mathrm{Sc}^{1/3}$$

where C and m are correlating constants. If there is no forced convection, then the Sherwood number is 2. This value can be derived theoretically by considering the molecular diffusion flux of species A from a sphere into an infinite sink of stagnant fluid B. Accordingly, the generalized equation becomes

$$\mathrm{Sh} = 2 + C\,\mathrm{Re}^m\,\mathrm{Sc}^{1/3}$$

For mass transfer into liquid streams, the equation of Brian and Hales[4]

$$\mathrm{Sh} = \frac{k_L D}{D_{AB}} = \left(4 + 1.21\,\mathrm{Pe}_{AB}^{2/3}\right)^{1/2} \qquad (30\text{-}7)$$

correlates data where the mass-transfer Peclet number, Pe_{AB}, is less than 10,000. From Table 30.1, recall Pe_{AB} is the product of the Reynolds and Schmidt numbers, Re · Sc. For Peclet numbers greater than 10,000, Levich[5] recommends the simpler relationship

$$\mathrm{Sh} = \frac{k_L D}{D_{AB}} = 1.01\,\mathrm{Pe}_{AB}^{1/3} \tag{30-8}$$

For mass transfer into gas streams, the Fröessling equation[6]

$$\mathrm{Sh} = \frac{k_c D}{D_{AB}} = 2 + 0.552\,\mathrm{Re}^{1/2}\,\mathrm{Sc}^{1/3} \tag{30-9}$$

correlates the data at Reynolds numbers ranging from 2 to 800 and Schmidt numbers ranging from 0.6 to 2.7. Data of Evnochides and Thodos[7] have extended the Fröessling equation to a Reynolds number range of 1500 to 12 000 under a Schmidt number range of 0.6 to 1.85.

Equations (30-7)–(30-9) can be used to describe forced convection mass-transfer coefficients only when the effects of free or natural convection are negligible; that is

$$\mathrm{Re} \geq 0.4\,\mathrm{Gr}^{1/2}\,\mathrm{Sc}^{-1/6} \tag{30-10}$$

The following correlation of Steinberger and Treybal[8] is recommended when the transfer occurs in the presence of natural convection

$$\mathrm{Sh} = \mathrm{Sh}_o + 0.347(\mathrm{Re}\,\mathrm{Sc}^{1/2})^{0.62} \tag{30-11}$$

where Sh_o is dependent on Gr Sc

$$\mathrm{Sh}_o = 2 + 0.569(\mathrm{GrSc})^{0.25} \qquad \mathrm{Gr\,Sc} \leq 10^8 \tag{30-12}$$

$$\mathrm{Sh}_o = 2 + 0.0254(\mathrm{GrSc})^{1/3}\,(\mathrm{Sc})^{0.244} \quad \mathrm{Gr\,Sc} \geq 10^8 \tag{30-13}$$