EES Ver. 8.637: #1733: Mechanical Engineering Department, Georgia Institute of Technology, Atlanta GA

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"Problem 2.8"
P_infinity=101330.
T_infinity=350.
T_s=350.
U_infinity=1.0
"x=0.01"
M_air=29
M_H2O=18

"Part A"
"Properties"
"The b.l. will be mrimarily made of air.  Use properties of pure air, for simplicity."
T_film=0.5*(T_s+T_infinity)
rho=density (air, P=P_infinity, T=T_film)
C_P=CP(air, T=T_film)
k=conductivity (air, T=T_film)
mu=viscosity(air, T=T_film)
Pr=Prandtl(air, T=T_film)
"Find Re_x at the three locations"
Re_x_air=rho*U_infinity*x/mu
D_12=(0.26e-4)*(T_infinity/298)^(3/2)
Sc=(mu/rho)/D_12
delta_air=5*x/sqrt(Re_x_air)
delta_ma_air/delta_air=Sc^(-1/3)

"Part b"
U_infinity_w=0.025
rho_w=density(water, P=P_infinity, x=0.0)
C_P_w=CP(Water, P=P_infinity, x=0)
mu_w=viscosity(Water, P=P_infinity, x=0)
Pr_w=Prandtl(Water, P=P_infinity, x=0)
Re_x_w=rho_w*U_infinity_w*x/mu_w
D_12_w=1.25e-9
Sc_w=(mu_w/rho_w)/D_12
delta_water=5*x/sqrt(Re_x_w)
"Note that for diffusion of chlorine in water, Sc>>1; therefore"
delta_ma_water/delta_water=Sc_w^(-1/3)
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Problem 2.8

$P_\infty = 101330$

$T_\infty = 350$

$T_s = 350$

$U_\infty = 1$

x=0.01

$M_{air} = 29$

$M_{H2O} = 18$

Part A

Properties

The b.l. will be mrimarily made of air. Use properties of pure air, for simplicity.

$$T_{film} = 0.5 \cdot [T_s + T_\infty]$$

$$\rho = \rho['Air', P = P_\infty, T = T_{film}]$$

$$C_P = \mathbf{Cp}['Air', T = T_{film}]$$

$$k = \mathbf{k}['Air', T = T_{film}]$$

$$\mu = \mathbf{Visc}['Air', T = T_{film}]$$

$$Pr = \mathbf{Pr}['Air', T = T_{film}]$$

Find Re_x at the three locations

$$Re_{x,air} = \rho \cdot U_\infty \cdot \frac{x}{\mu}$$

$$D_{12} = 0.000026 \cdot \left[\frac{T_\infty}{298}\right]^{[3/2]}$$

$$Sc = \frac{\mu}{\rho \cdot D_{12}}$$

$$\delta_{air} = 5 \cdot \frac{x}{\sqrt{Re_{x,air}}}$$

$$\frac{\delta_{ma,air}}{\delta_{air}} = Sc^{\left[\frac{-1}{3}\right]}$$

Part b

$$U_{\infty,w} = 0.025$$

$$\rho_w = \rho['Water', P = P_\infty, x = 0]$$

$$C_{P,w} = \mathbf{Cp}['Water', P = P_\infty, x = 0]$$

$$\mu_w = \mathbf{Visc}['Water', P = P_\infty, x = 0]$$

$$Pr_w = \mathbf{Pr}['Water', P = P_\infty, x = 0]$$

$$Re_{x,w} = \rho_w \cdot U_{\infty,w} \cdot \frac{x}{\mu_w}$$

$$D_{12,w} = 1.25 \times 10^{-9}$$

$$Sc_w = \frac{\mu_w}{\rho_w \cdot D_{12}}$$

$$\delta_{water} = 5 \cdot \frac{x}{\sqrt{Re_{x,w}}}$$

Note that for diffusion of chlorine in water, Sc>>1; therefore

$$\frac{\delta_{ma,water}}{\delta_{water}} = Sc_w^{\left[\frac{-1}{3}\right]}$$

SOLUTION

Unit Settings: SI K Pa J mass deg

(Table 1, Run 3)

C_P = 1008
$C_{P,w}$ = 4217
δ_{air} = 0.01244
$\delta_{ma,air}$ = 0.01456
$\delta_{ma,water}$ = 0.04535
δ_{water} = 0.009394
D_{12} = 0.00003309
$D_{12,w}$ = 1.250E-09
k = 0.0293
μ = 0.00002082
μ_w = 0.0002819
M_{air} = 29
M_{H2O} = 18
Pr = 0.7163
Pr_w = 1.788
P_∞ = 101330
$Re_{x,air}$ = 14533
$Re_{x,w}$ = 25496
ρ = 1.009
ρ_w = 958.4
Sc = 0.6237
Sc_w = 0.008889
T_{film} = 350
T_∞ = 350
T_s = 350
U_∞ = 1
$U_{\infty,w}$ = 0.025
x = 0.3

1 potential unit problem was detected.

Parametric Table: Table 1

	x	$Re_{x,air}$	Sc	δ_{air}	$\delta_{ma,air}$
Run 1	*0.01*	*484.4*	*0.6237*	*0.002272*	*0.002659*
Run 2	*0.1*	*4844*	*0.6237*	*0.007184*	*0.008408*
Run 3	*0.3*	*14533*	*0.6237*	*0.01244*	*0.01456*