"ME 345 Local and Average Convection Coefficient"

"Example Problem 6.4 from 6th Edition Incropera and DeWitt"

"Given Information"
L$ = 'water'
T_1 = 300 [K]
T_2 = 350 [K]
P = 101 [kPa]
u_infinity = 1 [m/sec]
h_lam_300 = C_lam_300*x^(-0.5)
h_turb_300 = C_turb_300*x^(-0.2)
h_lam_350 = C_lam_350*x^(-0.5)
h_turb_350 = C_turb_350*x^(-0.2)

C_lam_300 = 395 [W/(K*(m^1.5))]
C_turb_300 = 2330 [W/(K*(m^1.8))]
C_lam_350 = 477 [W/(K*(m^1.5))]
C_turb_350 = 3600 [W/(K*(m^1.8))]

$IFNOT Parametric Table
x=0.6 [m]
$endif

"Properties"
rho_300 = 1/**volume**(L$, ***T***=T_1, ***P***=P)
mu_300 = **viscosity**(L$,***T***=T_1,***P***=P)
rho_350 = 1/**volume**(L$, ***T***=T_2, ***P***=P)
mu_350 = **viscosity**(L$,***T***=T_2, ***P***=P)

"Calculating Transition Location"
Re_x_c_low = 10^5 [dim]
Re_x_c_mid = 5*10^5 [dim]
Re_x_c_high = 3*10^6 [dim]

x_c_300_low = (Re_x_c_low*mu_300)/(rho_300*u_infinity)
x_c_300_mid = (Re_x_c_mid*mu_300)/(rho_300*u_infinity)
x_c_300_high = (Re_x_c_high*mu_300)/(rho_300*u_infinity)

x_c_350_low = (Re_x_c_low*mu_350)/(rho_350*u_infinity)
x_c_350_mid = (Re_x_c_mid*mu_350)/(rho_350*u_infinity)
x_c_350_high = (Re_x_c_high*mu_350)/(rho_350*u_infinity)

"Calculating Average Convection Coefficients"
h_bar_300_low = 1/x*((C_lam_300/0.5*(x_c_300_low^0.5)) + C_turb_300/0.8*(x^0.8 - x_c_300_low^0.8))
h_bar_300_mid = 1/x*((C_lam_300/0.5*(x_c_300_mid^0.5)) + C_turb_300/0.8*(x^0.8 - x_c_300_mid^0.8))
h_bar_300_high = 1/x*((C_lam_300/0.5*(x^0.5)))

h_bar_350_low = 1/x*((C_lam_350/0.5*(x_c_350_low^0.5)) + C_turb_350/0.8*(x^0.8 - x_c_350_low^0.8))
h_bar_350_mid = 1/x*((C_lam_350/0.5*(x_c_350_mid^0.5)) + C_turb_350/0.8*(x^0.8 - x_c_350_mid^0.8))
h_bar_350_high = 1/x*((C_lam_350/0.5*(x^0.5)))

SOLUTION
Unit Settings: SI K kPa kJ mass deg

$C_{lam,300}$ = 395 [W/(K*(m^1.5))]
$C_{turb,300}$ = 2330 [W/(K*(m^1.8))]
$\bar{h}_{300,high}$ = 1020 [W/(K*m^2)]
$\bar{h}_{300,mid}$ = 1624 [W/(K*m^2)]
$\bar{h}_{350,low}$ = 4747 [W/(K*m^2)]
$C_{lam,350}$ = 477 [W/(K*(m^1.5))]
$C_{turb,350}$ = 3600 [W/(K*(m^1.8))]
$\bar{h}_{300,low}$ = 2931 [W/(K*m^2)]
$\bar{h}_{350,high}$ = 1232 [W/(K*m^2)]
$\bar{h}_{350,mid}$ = 3695 [W/(K*m^2)]

$h_{lam,300}$ = 509.9 [W/(K*m^2)]
$h_{turb,300}$ = 2581 [W/(K*m^2)]
L$ = 'water'
μ_{350} = 0.0003688 [N-sec/m^2]
$Re_{x,c,high}$ = 3.000E+06
$Re_{x,c,mid}$ = 500000
ρ_{350} = 973.7 [kg/m^3]
T_2 = 350 [K]
x = 0.6 [m]
$x_{c,300,low}$ = 0.08568 [m]
$x_{c,350,high}$ = 1.136 [m]
$x_{c,350,mid}$ = 0.1894 [m]

$h_{lam,350}$ = 615.8 [W/(K*m^2)]
$h_{turb,350}$ = 3987 [W/(K*m^2)]
μ_{300} = 0.0008538 [N-sec/m^2]
P = 101 [kPa]
$Re_{x,c,low}$ = 100000
ρ_{300} = 996.6 [kg/m^3]
T_1 = 300 [K]
u_∞ = 1 [m/sec]
$x_{c,300,high}$ = 2.57 [m]
$x_{c,300,mid}$ = 0.4284 [m]
$x_{c,350,low}$ = 0.03787 [m]

No unit problems were detected.

KEY VARIABLES
$x_{c,300,low}$ = 0.08568 [m]
$x_{c,300,mid}$ = 0.4284 [m]
$x_{c,300,high}$ = 2.57 [m]
$\bar{h}_{300,low}$ = 2931 [W/(K*m^2)]
$\bar{h}_{300,high}$ = 1020 [W/(K*m^2)]
$\bar{h}_{300,mid}$ = 1624 [W/(K*m^2)]
$x_{c,350,low}$ = 0.03787 [m]
$x_{c,350,mid}$ = 0.1894 [m]
$x_{c,350,high}$ = 1.136 [m]
$\bar{h}_{350,low}$ = 4747 [W/(K*m^2)]
$\bar{h}_{350,mid}$ = 3695 [W/(K*m^2)]
$\bar{h}_{350,high}$ = 1232 [W/(K*m^2)]

Parametric Table: Table 2

	x [m]	$h_{lam,350}$ [W/(K*m^2)]	$h_{turb,350}$ [W/(K*m^2)]
Run 1	0.001	*15084*	*14332*
Run 2	0.025	*3017*	*7529*
Run 3	0.05	*2133*	*6554*
Run 4	0.075	*1742*	*6044*
Run 5	0.1	*1508*	*5706*
Run 6	0.125	*1349*	*5457*
Run 7	0.15	*1232*	*5261*
Run 8	0.175	*1140*	*5101*
Run 9	0.2	*1067*	*4967*
Run 10	0.225	*1006*	*4851*
Run 11	0.25	*954*	*4750*
Run 12	0.275	*909.6*	*4661*
Run 13	0.3	*870.9*	*4580*
Run 14	0.325	*836.7*	*4507*
Run 15	0.35	*806.3*	*4441*
Run 16	0.375	*778.9*	*4380*
Run 17	0.4	*754.2*	*4324*
Run 18	0.425	*731.7*	*4272*
Run 19	0.45	*711.1*	*4223*
Run 20	0.475	*692.1*	*4178*
Run 21	0.5	*674.6*	*4135*

Parametric Table: Table 2

	x [m]	$h_{lam,350}$ [W/(K*m²)]	$h_{turb,350}$ [W/(K*m²)]
Run 22	0.525	*658.3*	*4095*
Run 23	0.55	*643.2*	*4057*
Run 24	0.575	*629*	*4021*
Run 25	0.6	*615.8*	*3987*