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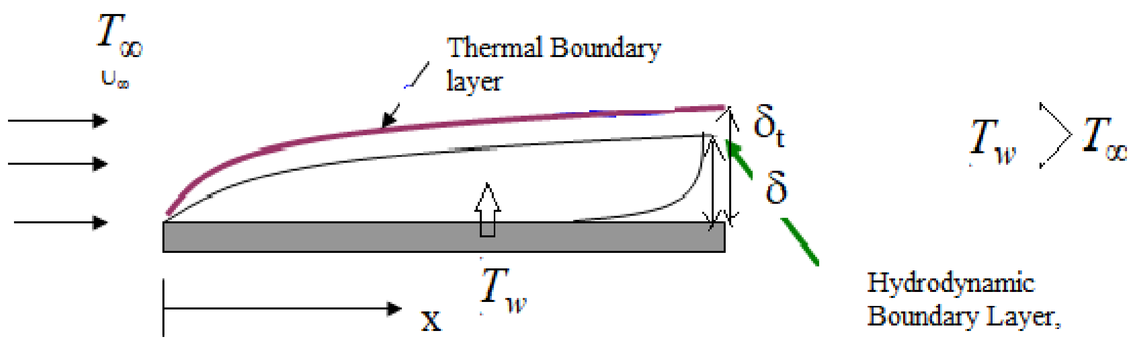
5. Heat transfer coefficients, thermal boundary layer



$$q = -kA\left(\frac{\partial T}{\partial y}\right)_{y=0} = Ah\left(T_w - T_\infty\right)$$

Laminer flow heat transfer to flat plate

$$\overline{Nu} = 0.664\,\mathrm{Re}^{1/2}\,\mathrm{Pr}^{1/3}$$

Example:

T_∞ = 20 °C
$v = 15\ m/s$
T_w = 110 °C
x = 0.5 m
q = ?

$q = h\,A\,(T_w - T_\infty)$

$T_f = \frac{T_w + T_\infty}{2} = \frac{110+20}{2} = 65\ °C = 338\ K$

Physical properties of air at 338 K (Table 5) by interpolation,

$$\rho = 1.041\ kg/m^3$$
$$C_p = 1.0082\ kj/kg°C$$
$$\mu = 2.02 * 10^{-5}\ kg/ms$$
$$k = 0.02912\ W/m°C$$
$$Pr = 0.699$$

$Re = \frac{x\,v\,\rho}{\mu} = \frac{0.5\ m * 15\ m/s * 1.041\ kg/m^3}{2.02 * 10^{-5}\ kg/ms} = 386509 < 5 * 10^5$ (Laminar flow)

$Nu = 0.664 * Pr^{1/3} * Re^{1/2}$

$Nu = 0.664 * (0.699)^{1/3} * (386509)^{1/2} = 366.36$

$Nu = \frac{h\,x}{k} = 366.36 = \frac{h\ \ 0.5\ m}{0.02912\ W/m°C}$

$h = 21.34\ W/m^2°C$

$q = h\,A\,(T_w - T_\infty)$

$q = 21.34 * 0.5^2 * (110 - 20)$

$q = 480.15\ W$