Example.

A highly conducting thin plate $L = 2\,m$ long separates the hot and cold airstreams flowing on both sides parallel to the plate surface. The hot stream is at the atmospheric pressure and has a temperature of $T_h = 250^\circ C$ and a velocity $u_h = 50\,m/s$. The cold stream is also at atmospheric pressure and has temperature of $T_c = 70^\circ C$ and velocity $u_c = 15\,m/s$. Determine;

(i) average heat transfer coefficient for the hot air stream
(ii) average . . . . . cold air stream.
(iii) total heat transfer rate between the stream per meter width of the separating plate.

→ air, 1atm
$T_h = 250^\circ C$, $u_h = 50\,m/s$
2 m
$T_c = 70^\circ C$, $u_c = 15\,m/s$

external flow, fluid properties at

$T_m = \frac{T_h + T_c}{2} = 160^\circ C$

$k = 0.0351$ $\quad Pr = 0.7014$ $\quad \nu = 2.935 \times 10^{-5}$

flow over flat plate:

hot:

$Re_L = \frac{VL}{\nu} = \frac{50(2)}{2.935 \times 10^{-5}}$

$= 336,304$ (turbulent)

eqn. 10.16: $Nu = 0.037\, Re^{0.8}\, Pr^{1/3}$

$= 594.1$

$\rightarrow h_h = 96.04\ W/m^2.K$

cold:

$Re_c = \frac{VL}{\nu} = \frac{15(2)}{2.935 \times 10^{-5}} = 1008403$

$\rightarrow Nu = 2088.2$

$h_c = 36.66\ W/m^2.K$

Total heat transfer rate:

$\dot{Q}_h = h_h A (T_h - T_w)$
$\dot{Q}_c = h_c A (T_w - T_c)$
$\} \dot{Q}_h = \dot{Q}_c$

$h_h A (T_h - T_w) = h_c A (T_w - T_c)$

$\rightarrow T_w = \frac{h_c T_c + h_h T_h}{(h_c + h_h)}$

$= 473.3\ K$

$= 200.3^\circ C$

$\rightarrow \frac{\dot{Q}}{\text{Width}} = h_h (2)(T_h - T_w)$

$= 9456.4\ \frac{W}{m}$ *