CONVECTION CALCULATION EXAMPLE: COOLING RATE ON A FLAT PLATE

Air at a pressure of 6 kN/m² and a temperature of 300°C flows with a velocity of 10 m/s over a flat plate 0.5 m long.

Estimate the cooling rate per unit width of the plate needed to maintain it at a surface temperature of 27°C.

1- Assumptions

2- Fluid properties at $p = 1$ atm and $T_f =$

\[ \nu = \] 

\[ k = \] 

\[ \text{Pr} = \]
To be a little bit more accurate, we may account for the effects of pressure on viscosity (viscosity $\propto 1/$pressure) to obtain a corrected viscosity at $p_e = 6 \text{ kN/m}^2$:

$$
\text{viscosity} = \frac{1}{p_e}
$$

3. Analysis

Governing equation:

The only unknown is $\bar{h}$, which can be determined using an appropriate convection correlation.

Flow regime:

$\Rightarrow$

Average Nusselt number:

Average convection coefficient:

Therefore, the required cooling rate per unit width of plate is:
<table>
<thead>
<tr>
<th>$T$ (K)</th>
<th>$\rho$ (kg/m$^3$)</th>
<th>$c_p$ (kJ/kg · K)</th>
<th>$\mu \cdot 10^7$ (N · s/m$^2$)</th>
<th>$\nu \cdot 10^6$ (m$^2$/s)</th>
<th>$k \cdot 10^3$ (W/m · K)</th>
<th>$\alpha \cdot 10^6$ (m$^2$/s)</th>
<th>$Pr$</th>
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