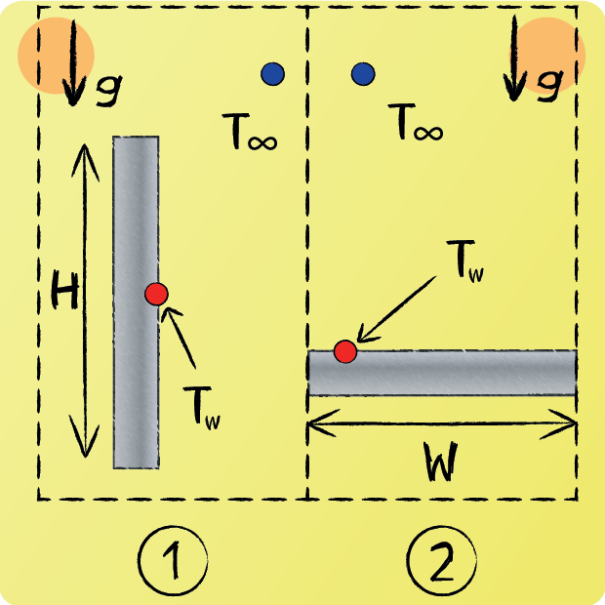
Exam Preparation Convection 02



Two heat-emitting surfaces (case 1: H height, case 2: W width) with the respective wall temperatures T_{H} and T_{W} are given. The quiescent evironment has a temperature T_{∞}. Determine the ratio of the two heat transfer coefficients α_{H} and A_{W} of the surfaces.

For the mean heat transfer at natural convection (vertical plate (H), laminar boundary layer, isothermal surface (HTC 17))

$$\overline{Nu}_{\mathrm{H}} = 0,535 \cdot (Gr_{\mathrm{H}} Pr)^{1/4}$$

and the mean heat transfer at natural convecetion (horizontal plate (B), laminar boundary layer, isothermal surface (HTC 22a),

$$\overline{Nu}_{\mathrm{B}} = 0,54 \cdot (Gr_{\mathrm{B}} Pr)^{1/4}$$

under the condition

$$Gr_{\mathrm{L}} Pr < 1 \cdot 10^6 < Gr_{\mathrm{L,krit.}} Pr$$

with the Grashof-Numbers Gr_{H} und Gr_{B}

$$Gr_{\mathrm{H}} = \frac{\frac{1}{T_\infty} g (T_{\mathrm{H}} - T_\infty) H^3}{\nu^2}$$

and

$$Gr_{\mathrm{B}} = \frac{\frac{1}{T_\infty} g (T_{\mathrm{B}} - T_\infty) B^3}{\nu^2}$$

,a relation for the heat transfer α at both surfaces can be developed

$$\overline{\alpha}_{\mathrm{L}} = \frac{\overline{Nu}_{\mathrm{L}} \lambda_\infty}{L}$$

The ratio of both heat transfer coefficients leads to:

$$\frac{\overline{Nu}_{\mathrm{B}}}{\overline{Nu}_{\mathrm{H}}} = \frac{0,54 \left(Gr_{\mathrm{B}} Pr\right)^{\left(\frac{1}{4}\right)}}{0,535 \left(Gr_{\mathrm{H}} Pr\right)^{\left(\frac{1}{4}\right)}}$$

simplified to

$$\left(\frac{\overline{\alpha}_{\mathrm{B}}}{\overline{\alpha}_{\mathrm{H}}}\right)^4 = \frac{0,54^4 \cdot (T_{\mathrm{B}} - T_\infty) \cdot H}{0,535^4 \cdot (T_{\mathrm{H}} - T_\infty) \cdot B}$$

$$\overline{\alpha}_{\mathrm{B}} = 0,645 \cdot \overline{\alpha}_{\mathrm{H}}$$