Convection heat transfer coefficient over Lake Constance

Determination of the convection heat transfer coefficient over Lake Constance.

1. Task 1 in Stefan flow

In this task, the convection heat transfer coefficient of the air flow must be calculated under the atmospheric conditions given in Fig. (1) over Lake Constance.

2. Answer

2.1. *Given parameters*

- 1: Pressure $P = 1$ bar,
- 2: Temperature $T = 20\,°\mathrm{C}$,
- 3: Air flow velocity $v = 1\ \mathrm{mm\,s^{-1}}$,
- 4: Length $L = 61.4\,\mathrm{km}$.

2.2. *Air properties under atmospheric conditions*

Refering to the table 4 in the FS, the following air properties can be read:

- 1: Thermal conductivity $\lambda = 25.69 \cdot 10^{-3}\,\mathrm{W\,m^{-1}\,K^{-1}}$,
- 1: Heat capacity $c_p = 1007 \cdot 10^{3}\,\mathrm{J\,kg^{-1}\,K^{-1}}$,
- 2: Kinematic viscosity $\nu = 15.35 \cdot 10^{-6}\,\mathrm{m^2\,s^{-1}}$,
- 3: Prandtl number $Pr = 0.7148$.

2.3. *Determination of the Reynolds number*

$$Re_L = \frac{v \cdot L}{\nu} = \frac{10^{-3} \cdot 61.4 \cdot 10^{3}}{15.35 \cdot 10^{-6}} = 4 \cdot 10^{6}. \tag{2.1}$$

2.4. *Determination of the Nusselt number*

Since $Re > 2 \cdot 10^5$ and $5 \cdot 10^5 < Re < 10^7$, the Nusselt number can be reported using WÜK. 6 as follows:

$$\bar{Nu} \approx 0.036 Pr^{0.43} \cdot \left(Re_L^{0.8} - 9400\right) = 5.667 \cdot 10^{3}, \tag{2.2}$$

$$\bar{\alpha} = \frac{\lambda \cdot \bar{Nu}}{L} = 2.371 \cdot 10^{-3}\,\mathrm{W\,m^{-2}\,K^{-1}}. \tag{2.3}$$

2.5. *Determination of the mass transfer coefficient*

$$\bar{g} = \frac{\bar{\alpha}}{c_p} = \frac{2.371 \cdot 10^{-3}}{1007} = 2.0 \cdot 10^{-6}\,\mathrm{kg\,m^{-2}\,s^{-1}}. \tag{2.4}$$

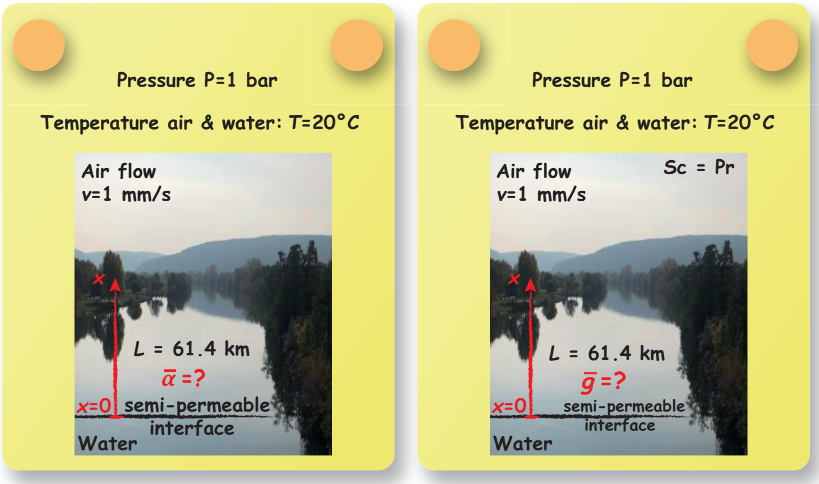

FIGURE 1. Problem definition.