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Mechanical Design 444
System Simulation Notes

Thermophysical Properties of Dry Air[1]

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[1] **Kröger, D.G.**, *Air-Cooled Heat Exchangers And Cooling Towers,* PennWell Corporation, Tulsa, OK., USA, 2004.

1. Conversion of units

Degrees celsius (°C) to kelvin (K)

$$T\ \mathrm{K} = t\ {}^\circ\mathrm{C} + 273.15 \tag{1}$$

Dimensionless temperature (numeric value of kelvin temperature)

$$\tau = T/\mathrm{K} \tag{2}$$

2. Constants

Gas constant for dry air

- Gas Constant $R_{\mathrm{air}} = 287.08\ \mathrm{J/(kg{\cdot}K)}$

3. Standard atmosphere

Standard atmospheric conditions as sealevel for dry air

- Air pressure $P_{\mathrm{atm}} = 101\,325\ \mathrm{Pa}$
- Air temperature $T_{\mathrm{atm}} = 293.15\ \mathrm{K}$ (20 °C)
- Air density $\rho_{\mathrm{atm}} = 1.204\ \mathrm{kg/m^3}$

4. Dry air properties

The following thermophysical properties is for dry air from 220 K to 380 K at standard atmospheric pressure of 101.325 kPa.

- Density

$$\rho_{\mathrm{air}} = \frac{P_{\mathrm{atm}}}{R_{\mathrm{air}} T} \qquad [\,\mathrm{kg/m^3}\,] \tag{3}$$

- Specific heat with $\tau = T/\mathrm{K}$

$$\begin{aligned} c_{p_{\mathrm{air}}} &= 1045.356 - 0.3161783\ \tau \\ &\quad + 7.083\,814{\times}10^{-4}\ \tau^2 - 2.705\,209{\times}10^{-7}\ \tau^3 \end{aligned} \qquad [\,\mathrm{J/(kg{\cdot}K)}\,] \tag{4}$$

- Dynamic viscosity with $\tau = T/\mathrm{K}$

$$\begin{aligned} \mu_{\mathrm{air}} &= 2.287\,93{\times}10^{-6} + 6.259\,793{\times}10^{-8}\ \tau \\ &\quad - 3.131\,956{\times}10^{-11}\ \tau^2 + 8.150\,38{\times}10^{-15}\ \tau^3 \end{aligned} \qquad [\,\mathrm{kg/(m{\cdot}s)}\,] \tag{5}$$

- Kinematic viscosity

$$\nu_{\mathrm{air}} = \frac{\mu_{\mathrm{air}}}{\rho_{\mathrm{air}}} \qquad [\,\mathrm{m^2/s}\,] \tag{6}$$

- Thermal conductivity with $\tau = T/\mathrm{K}$

$$\begin{aligned} k_{\mathrm{air}} &= -4.937\,787{\times}10^{-4} + 1.018\,078{\times}10^{-4}\ \tau \\ &\quad - 4.627\,937{\times}10^{-8}\ \tau^2 + 1.250\,603{\times}10^{-11}\ \tau^3 \end{aligned} \qquad [\,\mathrm{W/(m{\cdot}K)}\,] \tag{7}$$

- Prandtl number

$$Pr_{\mathrm{air}} = \frac{\mu_{\mathrm{air}}\ c_{p_{\mathrm{air}}}}{k_{\mathrm{air}}} \qquad [] \qquad (8)$$

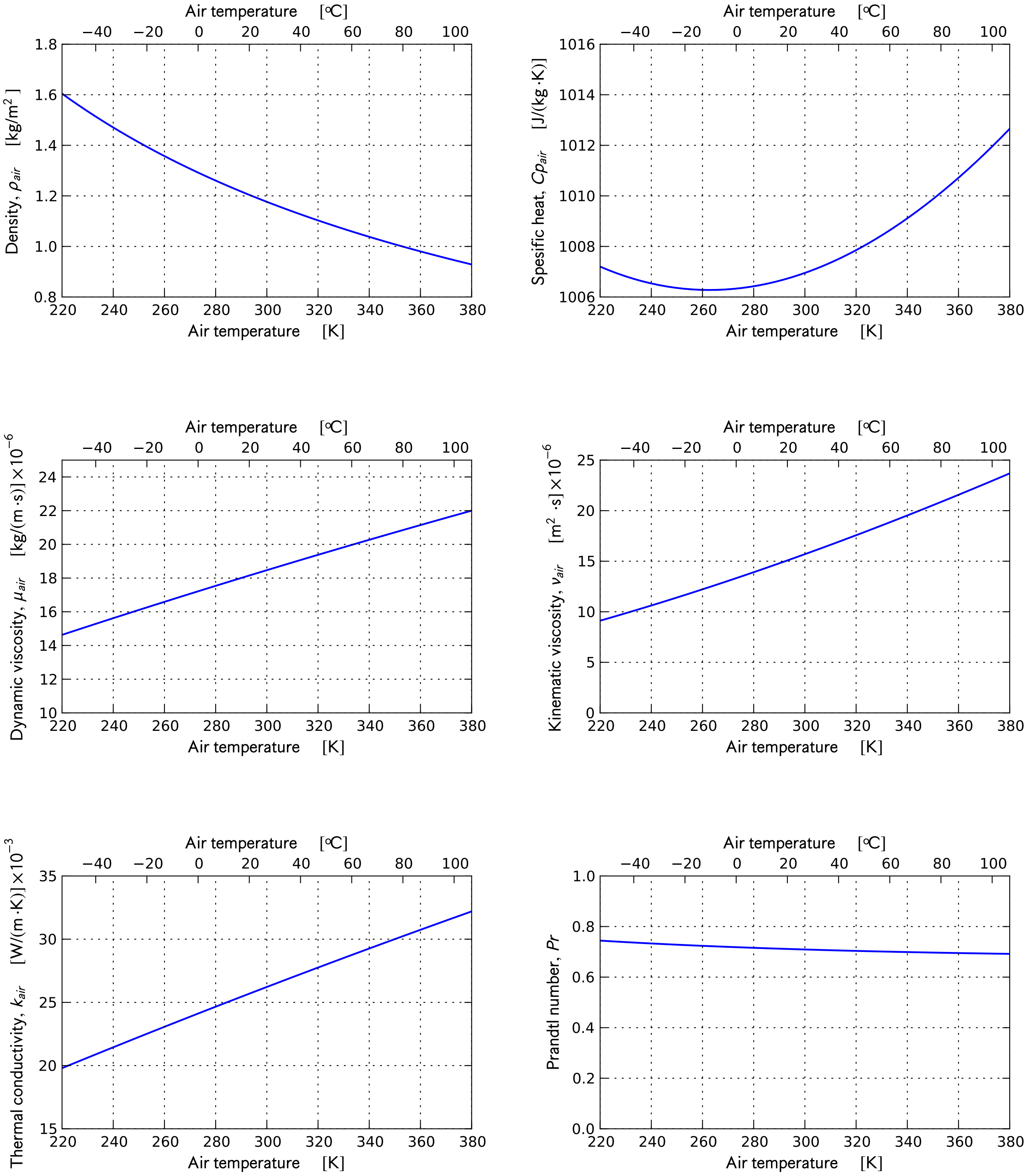

Figure 1: Thermophysical properties is for dry air