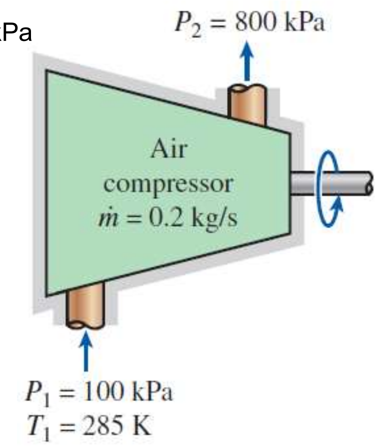

Given:
Air is compressed by an adiabatic compressor from 100 kPa and 12°C to a pressure of 800 kPa at a steady rate of 0.2 kg/s.

$P_1 := 100\ \text{kPa}$ $T_1 := 12\ °\text{C}$ $P_2 := 800\ \text{kPa}$ $m' := 0.2\ \frac{\text{kg}}{\text{s}}$

Required:
If the isentropic efficiency is 80%, determine the air temperature at the exit and the required power input for the compressor.

Solution:
The isentropic efficiency is defined as

$\eta_C := 80\ \%$

Using the definition of the isentropic efficiency of a compressor, the enthalpy at the outlet may be found by

$$\eta_C = \frac{h_{2s} - h_1}{h_{2a} - h_1} \qquad \text{or} \qquad h_{2a} = \frac{h_{2s} - h_1}{\eta_C} + h_1$$

Going to Table A-17 @ $T_1 = 285.2\ \text{K}$ shows that interpolation is need but will be approximated by $T_1 = 285\ \text{K}$.

$h_1 := 285.14\ \frac{\text{kJ}}{\text{kg}}$ $P_{r1} := 1.1584$

The relative pressure at state 2 may then be found by

$$P_{r2} := P_{r1} \cdot \left(\frac{P_2}{P_1}\right) = 9.2672$$

Going to Table A-17 @ $P_{r2} = 9.267$ shows that interpolation is needed.

$P_{ra} := 9.031$ $P_{rb} := 9.684$

$h_a := 513.32\ \frac{\text{kJ}}{\text{kg}}$ $h_b := 523.63\ \frac{\text{kJ}}{\text{kg}}$

$$h_{2s} := \frac{P_{r2} - P_{ra}}{P_{rb} - P_{ra}} \cdot \left(h_b - h_a\right) + h_a = 517.0\ \frac{\text{kJ}}{\text{kg}}$$

The actual enthalpy at the outlet may then be found by

$$h_{2a} := \frac{h_{2s} - h_1}{\eta_C} + h_1 = 575.0\ \frac{\text{kJ}}{\text{kg}}$$

Going to Table A-17 @ $h_{2a} = 575.0\ \frac{\text{kJ}}{\text{kg}}$ shows interpolation is needed.

$h_a := 565.17\ \frac{\text{kJ}}{\text{kg}}$ $h_b := 575.59\ \frac{\text{kJ}}{\text{kg}}$

$T_a := 560\ \text{K}$ $T_b := 570\ \text{K}$

$$\boxed{T_{2a} := \frac{h_{2a} - h_a}{h_b - h_a} \cdot \left(T_b - T_a\right) + T_a = 569.5\ \text{K}} \qquad T_{2a} = 296.3\ °\text{C}$$

Solution (contd.):
The required power is found by using the 1st Law for a steady flow device that is adiabatic, and has no ΔKE and ΔPE.

$$\frac{d}{dt}E_{sys} = \Sigma E'_{in} - \Sigma E'_{out}$$

$$0 = m'_{in} \cdot \left(h_{in} + \frac{V_{in}^{2}}{2} + g_e \cdot z_{in}\right) + W'_{in} - m'_{out} \cdot \left(h_{out} + \frac{V_{out}^{2}}{2} + g_e \cdot z_{out}\right)$$

$$0 = m'_{in} \cdot h_{in} + W'_{in} - m'_{out} \cdot h_{out}$$

Realizing that the mass flow rates are equal to each other because there is only one inlet and only one outlet, the required power may be found by

$$0 = m' \cdot \left(h_{in} - h_{out}\right) + W'_{in}$$

$$W'_{in} = m' \cdot \left(h_{out} - h_{in}\right)$$

$$\boxed{W'_{in} := m' \cdot \left(h_{2a} - h_1\right) = 57.98 \ kW}$$