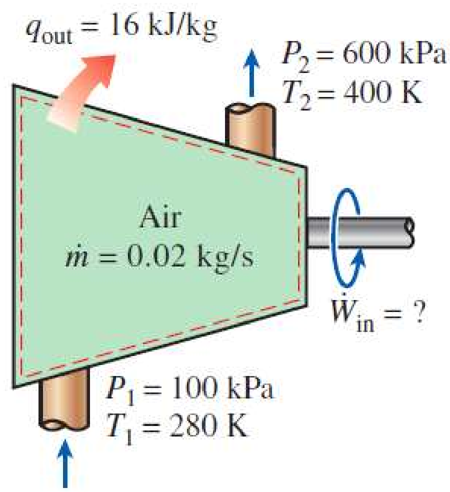
Given: $kJ := 1000J$

Air at 100 kPa and 280 K is compressed steadily to 600 kPa and 400 K. The mass flow rate of the air 0.02 kg/s, and a heat loss of 16 kJ/kg occurs during the process.



$q_{out} := 16\frac{kJ}{kg}$ $\quad m' := 0.02\frac{kg}{s}$

$P_1 := 100kPa$ $\quad P_2 := 600kPa$

$T_1 := 280K$ $\quad T_2 := 400K$

Required:

Assuming changes in potential and kinetic energy are negligible, determine the necessary power input to the compressor.

Solution:

Begining with the 1st Law

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

For a steady flow device this becomes

$$0 = \Sigma E'_{in} - \Sigma E'_{out}$$

Assuming the compressor is rigid and changes in kinetic and potential energy are negligible, the 1st Law expression becomes

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

Rearranging yields

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

Going to Table A-17 @ $T_1 = 280K$ and $T_2 = 400K$ shows

$h_1 := 280.13\frac{kJ}{kg}$ $\quad h_2 := 400.98\frac{kJ}{kg}$

The necessary power input is then given by

$$\boxed{W'_{in} := m'\cdot\left(q_{out} + h_2 - h_1\right) = 2.7\cdot kW}$$