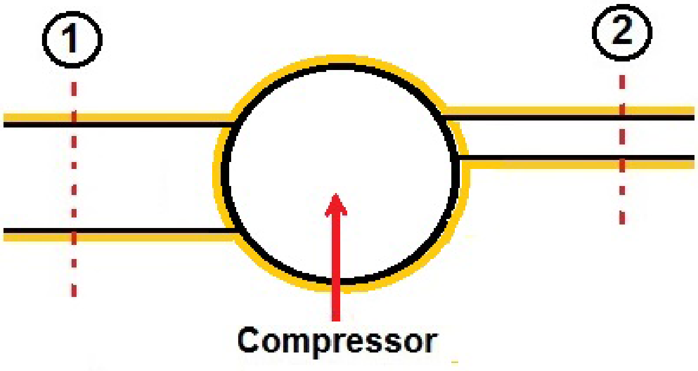
Solution to Problem 302B:

Air ($\mathcal{R} = 280m^2/s^2\ {}^\circ K$, $\gamma = 1.4$) at a temperature of $30^\circ C$ flows down a duct at a velocity of $30m/s$. The flow then proceeds through a compressor into a smaller duct where it travels at $200m/s$. If the rate of work done on the air by the compressor per unit mass of the air flowing through it is $1\ kW\ s/kg$ what is the temperature of the air in the duct downstream of the compressor? (Note: $1watt = 1\ kg\ m^2/s^3$; $1kW = 1000watts$)



Denoting the properties upstream by the subscript 1 and the properties downstream by the subscript 2, the energy equation yields

$$h_2^* - h_1^* \;=\; 40 \times 1000\ m^2/s^2 \tag{1}$$

or

$$c_p(T_2 - T_1) + \frac{1}{2}(u_2^2 - u_1^2) \;=\; 4 \times 10^4\ m^2/s^2 \tag{2}$$

Also with $c_p = \gamma\mathcal{R}/(\gamma - 1) = 980m^2/s^2\ {}^\circ K$ it follows that

$$T_2 \;=\; T_1 - \frac{1}{2 \times 980}(u_2^2 - u_1^2) + \frac{4 \times 10^4}{980} \;=\; 50.9^\circ C \tag{3}$$

Note that the temperature decreased due to the acceleration but increased due to the work done.