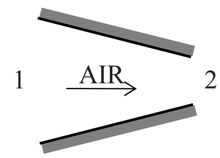
6-150 Air is accelerated in a nozzle. The density of air at the nozzle exit is to be determined.

Assumptions Flow through the nozzle is steady.

Properties The density of air is given to be 4.18 kg/m^3 at the inlet.

Analysis There is only one inlet and one exit, and thus $\dot{m}_1 = \dot{m}_2 = \dot{m}$. Then,



$$\dot{m}_1 = \dot{m}_2$$
$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$
$$\rho_2 = \frac{A_1}{A_2}\frac{V_1}{V_2}\rho_1 = 2\frac{120 \text{ m/s}}{380 \text{ m/s}}(4.18 \text{ kg/m}^3) = \mathbf{2.64 \ kg/m^3}$$

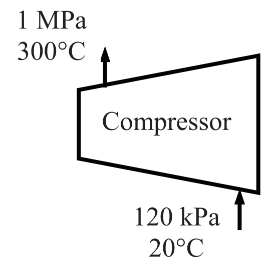
Discussion Note that the density of air decreases considerably despite a decrease in the cross-sectional area of the nozzle.

6-151 An air compressor consumes 4.5 kW of power to compress a specified rate of air. The flow work required by the compressor is to be compared to the power used to increase the pressure of the air.

Assumptions **1** Flow through the compressor is steady. **2** Air is an ideal gas.

Properties The gas constant of air is 0.287 kPa·m^3/kg·K (Table A-1).

Analysis The specific volume of the air at the inlet is



$$v_1 = \frac{RT_1}{P_1} = \frac{(0.287 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(20+273 \text{ K})}{120 \text{ kPa}} = 0.7008 \text{ m}^3/\text{kg}$$

The mass flow rate of the air is

$$\dot{m} = \frac{V_1}{v_1} = \frac{0.010 \text{ m}^3/\text{s}}{0.7008 \text{ m}^3/\text{kg}} = 0.01427 \text{ kg/s}$$

Combining the flow work expression with the ideal gas equation of state gives the flow work as

$$w_{\text{flow}} = P_2 v_2 - P_1 v_1 = R(T_2 - T_1) = (0.287 \text{ kJ/kg}\cdot\text{K})(300-20)\text{K} = 80.36 \text{ kJ/kg}$$

The flow power is

$$\dot{W}_{\text{flow}} = \dot{m} w_{\text{flow}} = (0.01427 \text{ kg/s})(80.36 \text{ kJ/kg}) = \mathbf{1.147 \ kW}$$

The remainder of compressor power input is used to increase the pressure of the air:

$$\dot{W} = \dot{W}_{\text{total,in}} - \dot{W}_{\text{flow}} = 4.5 - 1.147 = \mathbf{3.353 \ kW}$$