**PROBLEM 4.38**

**KNOWN:** Data is provided for a diffuser at steady state, through which air is flowing.

**Find:** Determine the ratio of the exit flow area to the inlet flow area, and the exit temperature.

**SCHEMATIC & GIVEN DATA:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td></td>
</tr>
<tr>
<td>$P_1 = 1$ bar</td>
<td>$P_2 = 1.13$ bar</td>
</tr>
<tr>
<td>$T_1 = 300$ K</td>
<td>$T_2 = ?$</td>
</tr>
<tr>
<td>$V_1 = 250$ m/s</td>
<td>$V_2 = 140$ m/s</td>
</tr>
</tbody>
</table>

**ENGR. MODELS:** The control volume shown in the schematic is at steady state. 1. For the control volume, $\dot{Q}_{cv} = \dot{W}_{cv} = 0$, and potential energy effects can be ignored. 2. Air is modeled as an ideal gas.

**ANALYSIS:** The mass rate balance reads $\dot{m}_2 = \dot{m}_1$, so

$$\frac{A_2 V_2^2}{V_2} = \frac{A_1 V_1^2}{V_1} \Rightarrow \frac{A_2}{A_1} = \frac{V_2^2}{V_1^2} \Rightarrow \frac{A_2}{A_1} = \left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$$  \hspace{1cm} (1)

The exit temperature, $T_2$, can be obtained using an energy rate balance:

$$0 = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}_1 [h_1 - h_2 + \frac{V_1^2}{2} - \frac{V_2^2}{2} + g \frac{1}{2} (z_2 - z_1)]$$

Using data from Table A-22,

$$h_2 = (300.19 \text{ kJ/kg}) + \frac{(250^2 - 140^2)}{2} \frac{\text{m}^2}{\text{s}^2} \frac{1 \text{ N}}{1 \text{ kg m/s}^2} \left| \frac{1 \text{ kJ}}{1000 \text{ Nm}} \right| = 321.64 \text{ kJ/kg}$$

Then, interpolating in Table A-22 for $h_2 = 321.64 \text{ kJ/kg}$

$$T_2 = 321.3 \text{ K} \leq T_a$$

Returning to Eq. (1)

$$\frac{A_2}{A_1} = \left(\frac{1 \text{ bar}}{1.13 \text{ bar}}\right)\left(\frac{321.3 \text{ K}}{300 \text{ K}}\right)\left(\frac{250 \text{ m/s}}{140 \text{ m/s}}\right)$$

$$\frac{A_2}{A_1} = 1.692$$