HW#3

(1) Air at 90 kPa and 10C enters an adiabatic diffuser steadily with a velocity of 180 m/s and leaves with a low velocity at a pressure of 100 kPa. The exit area of the diffuser is 4 times the inlet area. Determine (a) the exit temperature and (b) the exit velocity of the air.

Assumptions **1** This is a steady-flow process since there is no change with time. **2** Air is an ideal gas with variable specific heats. **3** Potential energy changes are negligible. **4** The device is adiabatic and thus heat transfer is negligible. **5** There are no work interactions.

Properties The enthalpy of air at the inlet temperature of 10°C = 283 K is h_1 = 283.14 kJ/kg (Table A-17).

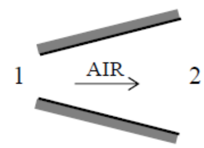
Analysis (*a*) There is only one inlet and one exit, and thus $\dot{m}_1 = \dot{m}_2 = \dot{m}$. We take diffuser as the system, which is a control volume since mass crosses the boundary. The energy balance for this steady-flow system can be expressed in the rate form as

$$\underbrace{\dot{E}_{in} - \dot{E}_{out}}_{\text{Rate of net energy transfer by heat, work, and mass}} = \underbrace{\Delta \dot{E}_{system}}_{\text{Rate of change in internal, kinetic, potential, etc. energies}} {}^{\nearrow 0 \text{ (steady)}} = 0$$

$$\dot{E}_{in} = \dot{E}_{out}$$

$$\dot{m}(h_1 + V_1^2/2) = \dot{m}(h_2 + V_2^2/2) \quad (\text{since } \dot{Q} \cong \dot{W} \cong \Delta pe \cong 0)$$

$$0 = h_2 - h_1 + \frac{V_2^2 - V_1^2}{2}$$,



or,

$$h_2 = h_1 - \frac{V_2^2 - V_1^2}{2} = 283.14 \text{ kJ/kg} - \frac{0 - (180 \text{ m/s})^2}{2}\left(\frac{1 \text{ kJ/kg}}{1000 \text{ m}^2/\text{s}^2}\right) = 299.3 \text{ kJ/kg}$$

From Table A-17, T_2 = **299.1 K**

(*b*) The exit velocity of air is determined from the conservation of mass relation,

$$\frac{1}{v_2}A_2V_2 = \frac{1}{v_1}A_1V_1 \longrightarrow \frac{1}{RT_2/P_2}A_2V_2 = \frac{1}{RT_1/P_1}A_1V_1$$

Thus,

$$V_2 = \frac{A_1T_2P_1}{A_2T_1P_2}V_1 = \frac{1}{5}\frac{(299.1 \text{ K})(90 \text{ kPa})}{(283 \text{ K})(100 \text{ kPa})}(180 \text{ m/s}) = \mathbf{34.2 \text{ m/s}}$$