Steam is accelerated in a nozzle from a velocity of 40 m/s to 300 m/s. The exit temperature and the ratio of the inlet-to-exit area of the nozzle are to be determined.

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

**Properties**
From the steam tables (Table A-6),

\[
\begin{align*}
P_1 &= 3 \text{ MPa} \\
T_1 &= 400\degree\text{C} \\
h_1 &= 3231.7 \text{ kJ/kg}
\end{align*}
\]

**Analysis**

(a) There is only one inlet and one exit, and thus \( \dot{m}_1 = \dot{m}_2 = \dot{m} \). We take nozzle 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

\[
\dot{E}_\text{in} - \dot{E}_\text{out} = \Delta E_{\text{system}} = 0
\]

or,

\[
h_2 = h_1 - \frac{V_2^2 - V_1^2}{2} = 3231.7 \text{ kJ/kg} - \frac{(300 \text{ m/s})^2 - (40 \text{ m/s})^2}{2} \left( \frac{1 \text{ kJ/kg}}{1000 \text{ m}^2/\text{s}^2} \right) = 3187.5 \text{ kJ/kg}
\]

Thus,

\[
\begin{align*}
P_2 &= 2.5 \text{ MPa} \\
T_2 &= 376.6\degree\text{C} \\
h_2 &= 3187.5 \text{ kJ/kg} \quad \nu_2 = 0.11533 \text{ m}^3/\text{kg}
\end{align*}
\]

(b) The ratio of the inlet to exit area is determined from the conservation of mass relation,

\[
\frac{1}{\nu_2} A_2 V_2 = \frac{1}{\nu_1} A_1 V_1 \quad \rightarrow \quad \frac{A_1}{A_2} = \frac{\nu_1}{\nu_2} \frac{V_2}{V_1} = \frac{(0.09938 \text{ m}^3/\text{kg})(300 \text{ m/s})}{(0.11533 \text{ m}^3/\text{kg})(40 \text{ m/s})} = 6.46
\]