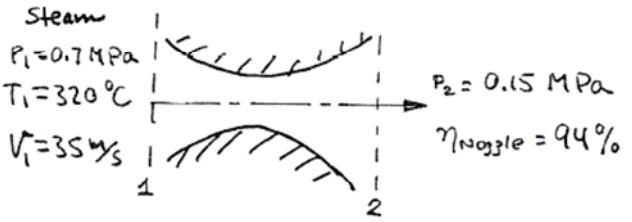
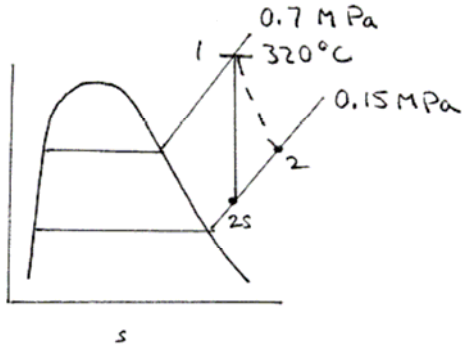
PROBLEM 6.139

KNOWN: Steady state operating data are provided for an insulated nozzle.

FIND: Determine the exit velocity.

SCHEMATIC & GIVEN DATA:





ENGR. MODEL: (1) The control volume shown in the figure is at steady state. (2) For the control volume, $\dot{Q}_{cv} = 0$, and potential energy effects are negligible.

ANALYSIS: The isentropic nozzle efficiency, Eq. 6.47, yields

$$V_2 = \sqrt{\eta_{Nozzle}}\, V_{2s} \tag{1}$$

where V_{2s} is the exit velocity for an isentropic expansion. Considering the isentropic expansion, reduction of mass and energy balances gives

$$\frac{V_{2s}^2}{2} = \frac{V_1^2}{2} + h_1 - h_{2s} \tag{2}$$

With data from Table A-4, $h_1 = 3100.9$ kJ/kg, $s_1 = 7.3697$ kJ/kg·K. Then, interpolating at 0.15 MPa with $s_{2s} = s_1$, $h_{2s} = 2752.8$ kJ/kg.

Substituting values in Eq. (2)

$$\frac{V_{2s}^2}{2} = \frac{(35\ \text{m/s})^2}{2} + (3100.9 - 2752.8)\frac{\text{kJ}}{\text{kg}}\left|\frac{1000\ \text{N·m}}{\text{kJ}}\right|\left|\frac{1\ \text{kg·m}}{1\ \text{N·s}^2}\right|$$

giving

$$V_{2s} = 835.1\ \text{m/s} \Rightarrow V_2 = \sqrt{0.94}\,(835.1) = 809.7\ \text{m/s} \quad \leftarrow V_2$$