PROBLEM 10.58

**KNOWN:** Air is the working fluid in an Ericsson refrigeration cycle. Data are known at various locations.

**EINN:** Determine (a) the heat transfer for the isothermal expansion, (b) the net work per unit mass of air flow, and (c) the coefficient of performance.

**SCHEMATIC & GIVEN DATA:**

**ENGINEERING MODEL:** (1) Each component is analyzed as a control volume at steady state. (2) All processes are internally reversible. (3) The compression and expansion processes are isothermal. (4) Kinetic and potential energy effects are negligible. (5) The air behaves as an ideal gas.

**ANALYSIS:**

(a) Determine \( \dot{Q}_{in} / m \) from an energy balance on the turbine

\[
\dot{Q} = \dot{Q}_{in} - \dot{W}_t + m \left( h_4 - h_5 \right)
\]

or

\[
\dot{Q}_{in} / m = \dot{W}_t / m
\]

The turbine work is evaluated using Eq. 6.56

\[
\dot{W}_t = - \int_3^4 v dp = -RT_3 \ln \frac{p_4}{p_3} = RT_3 \ln \frac{p_5}{p_4} = \left( \frac{8.314 \text{ J}}{28.97 \text{ kJ/kg}} \right)(270) \ln(3) = 85.13 \text{ kJ/kg}
\]

\[
\frac{\dot{Q}_{in}}{m} = 85.13 \text{ kJ/kg}
\]

(b) The compressor work is evaluated similarly

\[
\frac{\dot{W}_c}{m} = RT_1 \ln \frac{p_4}{p_1} = \left( \frac{8.314}{28.97} \right)(310) \ln(3) = 97.69 \text{ kJ/kg}
\]

\[
\frac{\dot{W}_{comp}}{m} = \frac{\dot{W}_c}{m} - \frac{\dot{W}_t}{m} = 12.56 \text{ kJ/kg}
\]

(c) The coefficient of performance is

\[
\beta = \frac{\dot{Q}_{in}}{\dot{W}_{comp}} = 6.78
\]