PROBLEM 9.91

**KNOWN:** Air is the working fluid in an Ericsson cycle with data known at various locations.

**FIND:** Determine (a) the net power developed, (b) the thermal efficiency, and (c) the back-work ratio.

**SCHEMATIC & GIVEN DATA:**

![Diagram showing the Ericsson cycle with given data points and temperatures.]

- \( T_1 = 1400 \text{ K} \)
- \( P_1 = 10 \text{ bar} \)
- \( T_3 = 300 \text{ K} \)
- \( P_3 = 1 \text{ bar} \)
- \( \dot{m} = 5 \text{ kg/s} \)

**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) The turbine power is evaluated using

\[
W_t = -m \int_T^2 \nu dp = -mRT_1 \ln \left( \frac{P_2}{P_1} \right) \\
= -(5 \text{ kg/s}) \left( \frac{8.314}{2.897 \text{ kg.K.kg}^{-1}} \right) (1400 \text{ K}) \ln \left( \frac{1}{10} \right) \left| \frac{1 \text{ kW}}{1 \text{ kJ/s}} \right| = 4626 \text{ kW}
\]

and for the compressor

\[
W_c = mRT_3 \ln \left( \frac{P_3}{P_2} \right) = 991.2 \text{ kW}
\]

Thus, \( W_{\text{cycle}} = W_t - W_c = 3635 \text{ kW} \)

(b) The thermal efficiency is

\[
\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{1400} = 0.786 (78.6\%)
\]

Alternatively, from an energy balance on the turbine, \( Q_{\text{in}} = W_t \). Thus

\[
\eta = \frac{W_{\text{cycle}}}{Q_{\text{in}}} = \frac{3635}{4626} = 0.786
\]

(c) The back-work ratio is

\[
b_{\text{wr}} = \frac{W_c}{W_t} = \frac{991.2}{4626} = 0.214
\]