Mechanical Engineering Department
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1. A system of 1 kg of air inside a piston and cylinder apparatus executes a Carnot cycle. In your analysis for this problem, treat air as an ideal gas with constant specific heats $c_v = 0.718$ kJ/kgK and $c_p = 1.005$ kJ/kgK.

The air inside the piston and cylinder executes the following four processes that make up the Carnot cycle:

$1 \rightarrow 2$: This process rejects heat isothermally at 350 K as pressure changes from $P_1 = 100$ kPa to $P_2 = 500$kPa.

$2 \rightarrow 3$: This process only involves a work interaction that raises the air temperature from T_2 to $T_3 = 1400$K.

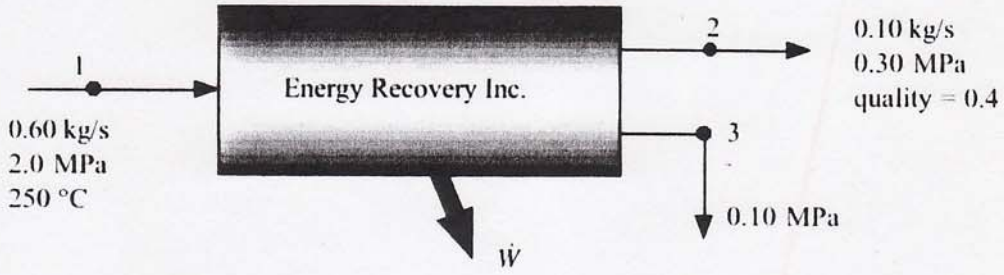
$3 \rightarrow 4$: This is an isothermal process that absorbs heat at 1400 K as pressure changes from P_3 to P_4.

$4 \rightarrow 1$: This process only involves a work interaction that lowers the air temperature from T_4 to T_1.

All four processes in the cycle have the required characteristics for processes in a Carnot cycle.

(a) Show the four processes above on a *T-s* diagram, indicating the locations of state points 1, 2, 3, and 4.
(b) Compute the changes of system entropy for processes $1 \rightarrow 2$ ($S_2 - S_1$) and $3 \rightarrow 4$ ($S_4 - S_3$).
(c) Determine the heat transfer for processes $1 \rightarrow 2$ (Q_{12}) and $3 \rightarrow 4$ (Q_{34}).
(d) Calculate the net work produced as the air in the system executes the cycle once.

2.



Recovery Energy Inc. claims that they have a device that will take a waste stream of steam at the conditions indicated above and produce power. Two streams leave the device at the two pressures indicated in the diagram. The device is insulated so that it essentially operates with zero heat transfer.

(a) The company indicates that this device produces a power output of 350 kW for the indicted conditions. Assuming this is true, determine the enthalpy per kg and temperature for the flow stream exiting at 3.

(b) For the inlet and exit flow conditions indicated in the diagram, what is the maximum power output that is thermodynamically possible?

(c) What is your conclusion regarding the accuracy of the power output claim made by Recovery Energy Inc.?