ME 201
Thermodynamics

Old Exam #3 Answers

Directions: Work all three (3) problems. The exam is open notes and open text book. All problems have equal weight.

Problem 1
An inventor claims to have designed a heat exchanger system that operates with air entering at 350 kPa, -17°C, and 0.05 kg/s and is heated to 70°C. Refrigerant-134a enters the other side as saturated vapor at 1.2 MPa at a rate of 0.25 kg/s. Determine the validity of this claim.

Answer:
The rate of entropy production is
\[ \dot{S}_{\text{prod}} = 0.00103 \text{ kW/K} \]
So it is possible for this to happen.

Problem 2
For several years a power plant has produced 500 MW of work from steam at 800°C and has rejected heat to a small lake at 20°C. For ecological reasons, the department of natural resources has asked for a 10% reduction in this heat rejection. How can this be accomplished and still maintain a power output of 500 MW? It may be reasonable to assume that the power plant operates as a Carnot cycle.

Answer:
The required thermal efficiency is
\[ \eta_{\text{th}} = 0.7473 \]
There are two ways to achieve this increase in thermal efficiency: lower the temperature of the small lake (probably not possible) or raise the temperature of the steam. Employing the second strategy, we now solve for the new steam temperature as
\[ T_H = 887°C \]
or we need to raise the steam temperature 87°C.

Problem 3
What does irreversibility imply about an adiabatic steam turbine which operates with inlet steam at 10 MPa and 700°C and exhausts at 0.2 MPa with a quality of 90%.

Solution:
Calculating the irreversibility of the turbine
\[ i = -179.2 \text{ kJ/(kg \cdot K)} \]
So that this turbine cannot operate in the way described. We could also do this by checking on the rate of entropy production.

\[ \dot{S} = (-179.2) \text{ kW/K} \]

which, again, means that this turbine cannot operate in the way described.