ME 354 THERMODYNAMICS - 2

26 June 1991

Midterm Examination M. Renksizbulut

- This is a two-hour, closed-book examination.
- There are 3 questions to be answered. Read the questions very carefully.
- It is your responsibility to write clearly and legibly.

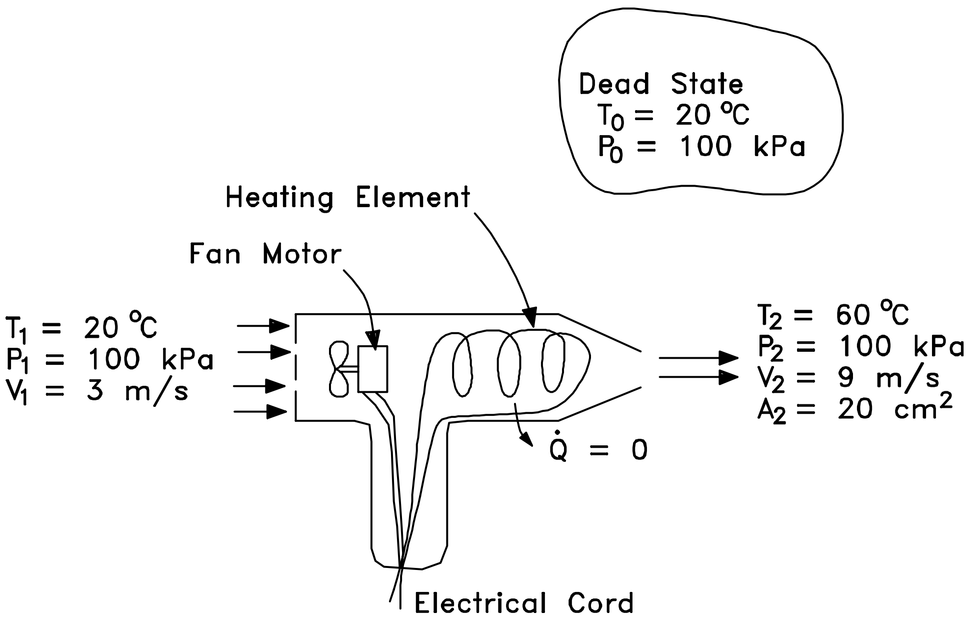
Question 1 (30%)

Consider a typical hair dryer as sketched below. All relevant information is given on the sketch.

10% 1) Find the power requirement $\dot{W}_{elec}$

10% 2) Find the rate of exergy destruction. What caused the destruction of exergy?

10% 3) Find the 2nd law efficiency η_2 which is defined here as the ratio of the increase in the exergy of air to the exergy input to the dryer. Comment on the very low value of η_2 that you will find.



Question 2 (35%)

5% A. What is exergy? What is the difference, if any, between reversible work and exergy?

B. The basic ideal Rankine cycle consists of a constant pressure boiler, an isentropic turbine, a constant pressure condenser, and an isentropic pump.

5% 1) Show the process on a T-s diagram.

5% 2) In addition to being cheap, non-toxic, and non-corrosive, what other features do we want from the working fluid? Does water have the features we want?

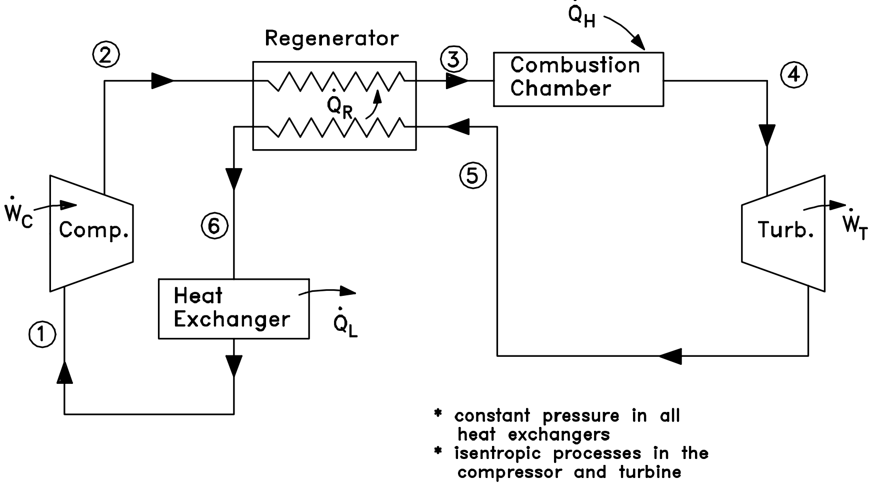
5% 3) What is the principle behind regeneration (in which some steam is extracted from the turbine and is used to heat the liquid water leaving the pump before it enters the boiler)?

5% 4) Instead of using a one-stage turbine, why do we use several stages with reheat in between?

C. The figure below shows an ideal regenerative Brayton cycle. The pressure ratio is defined as $r_P = P_2/P_1$

5% 1) Show the process on a T-s diagram.

5% 2) Give a physical explanation for the fact that regeneration, which increases cycle efficiency at lower r_p, begins to reduce efficiency at high r_p, while operating between the same T_1 and T_4. Use the T-s diagram to support your answer.



Question 3 (35%)

As shown in the figure below, the basic refrigeration cycle has been modified to include a heat exchanger. The working fluid is Refrigerant - 12, and its flow rate is $\dot{m} = 0.1\ kg/s$. All other relevant information is given in the figure. Assume that there is no heat transfer from the components to the surroundings other than ($\dot{Q}_L$ and $\dot{Q}_H$). Further assume that R-12 undergoes a reversible process in the compressor. There is negligible pressure drop in the heat exchangers and in the connecting tubes.

5% 1) Show that $h_4 = h_5$.

10% 2) Show the cyclic process on a T-s diagram. Label all states clearly.

10% 3) Calculate the COP (= benefit/penalty) of the refrigerator.

10% 4) Discuss the advantages and disadvantages of this modification to the basic refrigeration cycle. Be specific and support your statements with appropriate diagrams.