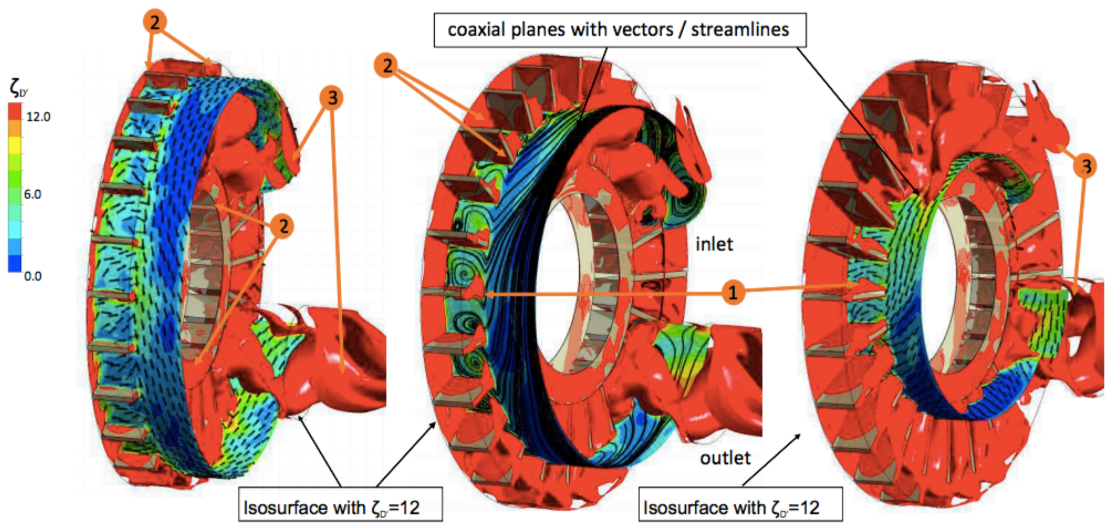


Figure 5. Losses in the side channel pump

(Image from: http://isromac-isimet.univ-lille1.fr/upload_dir/finalpaper/86.f14-4-3_isromac16.pdf)

ME 200 (Thermodynamics I)
Lecture 29

Even More Practice with the 2nd Law

Some concept and short answer questions from previous exams

Which of the following is an example of a closed system?
(i) The pump in a power plant
(ii) The compressor in a refrigerator
(iii) The battery of your laptop computer
(iv) The condenser in a heat pump.

The coefficient of performance of a reversible heat pump operating between two thermal reservoirs is always greater than that of a reversible refrigerator operating between the same two thermal reservoirs. [True or False]

Work transfer (e.g., by stirring with a paddle wheel) to an ideal gas enclosed in a rigid vessel does not change the entropy of the gas and its surroundings if the process in the tank is isothermal. [True or False]

The variable G where $G = H - TS$ where H is enthalpy, T is temperature and S is the entropy is a thermodynamic property. [True or False]

Helium has a molar mass (molecular weight) that is twice that of hydrogen. Consider two rigid vessels with identical volumes one filled with helium and the other with hydrogen. The pressure and temperature of the gases are identical and both gases can be assumed to be ideal gases. Which of the following statements is false?
(i) The mass of helium in the tank is twice that of hydrogen.
(ii) The hydrogen molecules have greater velocity than the helium molecules.
(iii) The specific volume of the helium is half that of the hydrogen.
(iv) The specific internal energy of helium and hydrogen in the tanks are the same.

Which of the following about an ideal gas is false?

(i) Specific enthalpy is only a function of temperature.
(ii) Specific internal energy is only a function of temperature.
(iii) The specific heat capacity at constant pressure is only a function of temperature.
(iv) Specific entropy is only a function of temperature.

An isentropic process of an ideal gas is always represented by pv^k = constant where k is a constant. [True or False]

The quasi-equilibrium expansion of an ideal gas in a piston-cylinder assembly is always isentropic. [True or False]

Which of the following statements is false?

(i) Entropy is always generated during heat transfer across a finite temperature difference.
(ii) The efficiencies of two Carnot engines operating between the same two thermal reservoirs, with one operating on water as the working fluid and the other operating on air as the working fluid are different.
(iii) The change in entropy of a closed system is the same for every process between two specified end states.
(iv) A process that violates the second law of thermodynamics need not violate the first law of thermodynamics.

A unit for the rate of entropy generation is kJ/kg-K. (True or False)

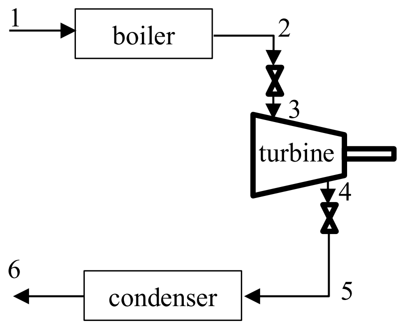
A steady flow system is always at steady state. (True or False)

For two different process paths between the same initial and final states, entropy generation for the two different paths is always equal. (True or False)

A vapor compression heat pump cycle provides heating at the rate of 25 kW while consuming 5 kW to operate the compressor. The surrounding of the heat pump is at -3°C while the heated space is at 27°C. Is this claim possible? (Yes or No) Show supporting calculations.

Example (SecondLaw_29)

A power system is devised consisting of the components shown in the figure. The states at various points in the system are also shown in the figure. Kinetic and potential energies may be neglected at all of states.



State 1:
liquid water
p_1 = 60 bar (abs)

State 2:
p_2 = 60 bar (abs)
T_2 = 540 °C

State 3:
p_3 = 40 bar (abs)

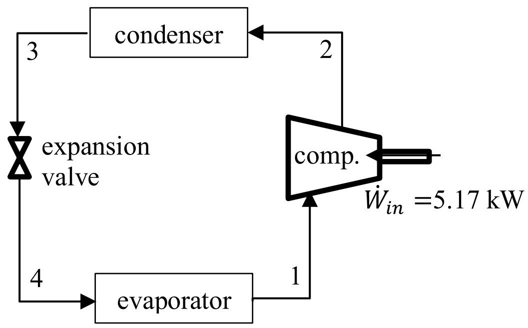
State 4:
p_4 = 5 bar (abs)
T_4 = 240 °C

State 5:
p_5 = 1 bar (abs)

State 6:
condensate
p_6 = 1 bar (abs)

a. Show the states and paths on a *T-s* diagram.
b. Determine the power developed by the turbine per unit mass flow rate of steam.
c. Calculate the rate of entropy production per unit mass flow rate for the valves and turbine.
d. Rank the components from those that contribute most to inefficient operation in the overall system to those that contribute the least.
e. If the goal is to increase the power developed per unit mass flow rate, which of the components (if any) might be eliminated? Explain.

Example (SecondLaw_30)
Consider the heat pump system shown below using R134a as the working fluid. The state conditions at various points in the system are also provided.



State 1:
$\dot{m}$ = 7 kg/min
p_1 = 2.4 bar (abs)

State 2:
p_2 = 9 bar (abs)
T_2 = 60 °C

State 3:
saturated liquid
p_3 = 9 bar (abs)

State 4:
p_4 = 2.4 bar (abs)

a. Determine the coefficient of performance for this heat pump.
b. If the valve were replaced by a turbine, power could be produced, thereby reducing the power requirement of the heat pump system. Would you recommend this power-saving measure? Explain.