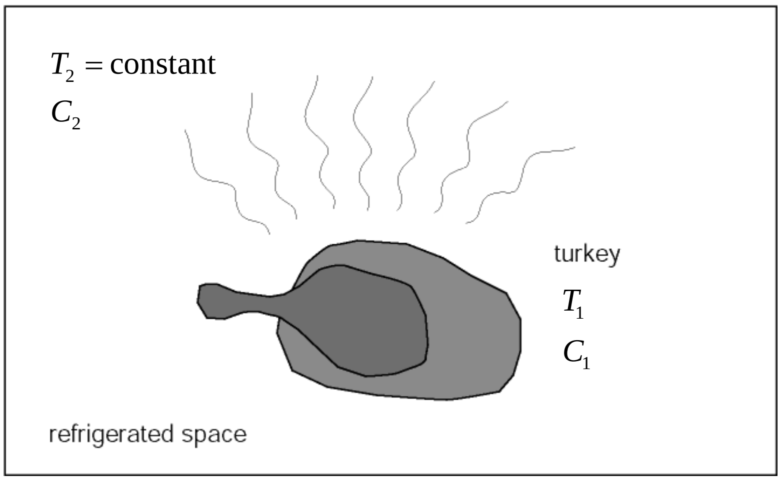
Unified Engineering Fall 2007
Thermodynamics & Propulsion Z. S. Spakovszky

(Add a short summary of the concepts you are using to solve the problem)

Problem T21

After a Thanksgiving dinner, a warm turkey is placed into a refrigerated space. The temperature of the refrigerated space is kept constant by a Carnot refrigerator. After a long period of time, the turkey and the refrigerated space reach thermal equilibrium. The turkey and the air in the refrigerated space have specific heat capacities C_1 and C_2, and the initial temperatures are T_1 and T_2 respectively.



a) What is the final temperature of the overall system (turkey and the refrigerated space) when thermal equilibrium is reached?

b) What is the change in entropy of the turkey?

c) What is the change in entropy of the refrigerated space?

d) How much entropy does the Carnot refrigerator's cooling system pump out of the refrigerated space, i.e. what is the change in entropy of the rest of the universe?

e) How much entropy is generated in the cooling process?

f) Indicate where and discuss how the entropy is generated. A sentence or two is expected.

(Add a short summary of the concepts you are using to solve the problem)

Problem T22/T23

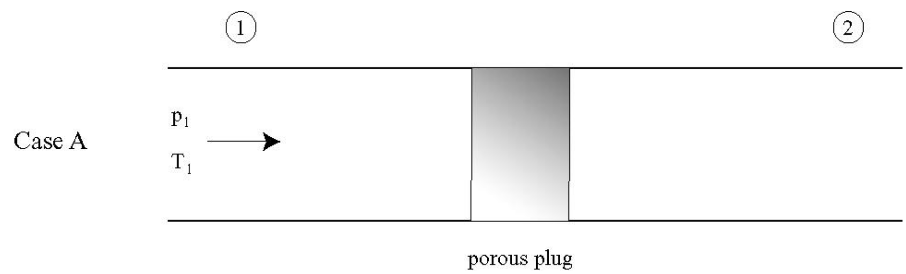
An ideal gas with constant specific heats slowly flows through a porous plug in a pipe of constant cross sectional area as shown below (case A). The pipe is perfectly insulated and the porosity of the plug is such that the static pressure ratio across the plug is $p_2/p_1 = 0.5$. The kinetic energy of the gas is negligible compared to its internal energy.

a) Determine the static temperature ratio T_2/T_1 and the density ratio ρ_2/ρ_1.

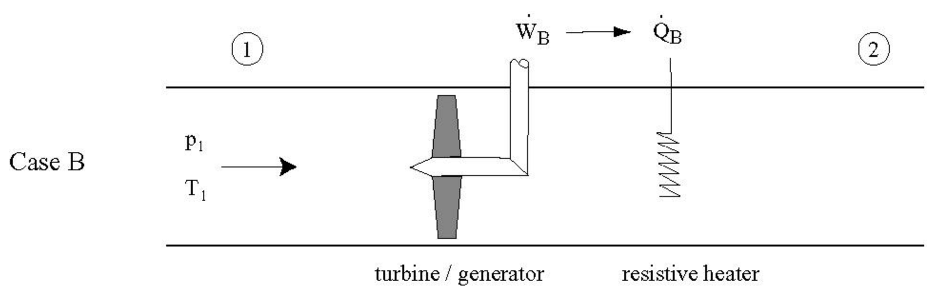
b) What is the entropy change across the plug?

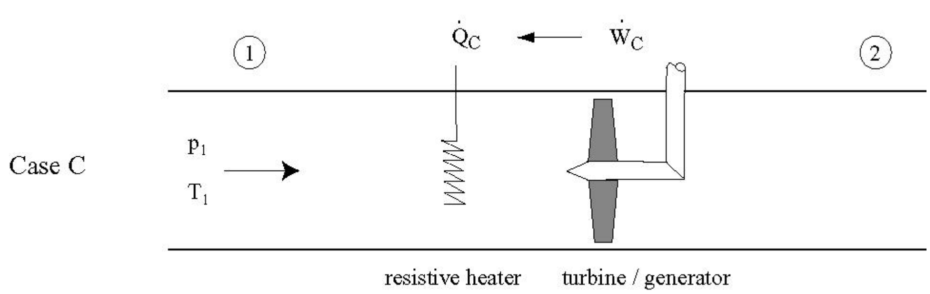
c) What is the entropy change of the surroundings?

d) Is this process reversible or irreversible? Why or why not?



The porous plug is now replaced by a combination of a turbine / generator and a resistive heater placed in the flow. The lossless turbine / generator extracts power at the rate Wdot, which is then put back into the flow as heat via the heater. The resistive heater has no frictional loss and the area is large enough such that there is no pressure drop. The heat can be added either downstream of the turbine (case B) or upstream of the turbine (case C).





a) Sketch the thermodynamic processes for each of the three cases in an h-s diagram.

b) What are the power levels required in cases B and C in order to obtain the same given pressure ratio p_2/p_1 as in case A? Identify which case requires a greater power level.

c) Compare the entropy added to the flow in the three cases and rank them by magnitude. Discuss your results. A sentence or two is expected perhaps bolstered by some equations.