ME 40 Spring 2021 Midterm 2

You are to evaluate a Brayton cycle.

A simple gas turbine provides 100 MW to an electric generator. The minimum temperature in the cycle is 27 °C, and the maximum temperature is 1327 °C. The lowest pressure in the cycle is 100 kPa, and the compressor pressure ratio is 14 to 1. The compressor actual outlet temperature is 425 °C. Assume turbine efficiency of 88%. Assume the environment temperature is 17 °C. You may use constant specific heat except where it is explicitly asked that you account for variations in specific heat i.e., item (f).

- Note the difference between power supplied to the electric generator given above in MW, and mass specific work asked for in the questions below.
- Some questions rely on answers from prior sections. If you do not know or do not trust your answers, use symbols, and keep working.
- Point rubric is indicated in parenthesis. Points in bold indicate questions where more detail is better if it is relevant.
- Show your work. This is a factor in assigning points.

You may make rough estimates of properties in the tables that need interpolation.

a) (**10**) Draw and label the components of the cycle and its path on state diagrams.
b) (10) Calculate the work and heat for the actual and isentropic compression processes.
c) (10) Calculate the compressor efficiency.
d) (5) Calculate the entropy generated in the polytropic process.
e) (5) Calculate the polytropic exponent.
f) (10) Calculate the entropy change of the fluid in the combustor using variable specific heat.
g) (5) Calculate the entropy generation in the heat addition process assuming there is a high, constant temperature reservoir at 1600 °C. You may round to the nearest value in the tables.
h) (5) Calculate the actual mass specific work of the turbine.
i) (5) Calculate the mass flow rate through the turbine.
j) (5) Calculate the efficiency of the cycle for the case with an isentropic and actual compressor.
k) (**10**) Provide an explanation for the difference in efficiency between the two processes?
l) (**10**) Would it make sense to install an intercooling process for the compression stage, why or why not? If not, why do we talk about intercooling for compressors?
m) (**10**) List ways the efficiency of this cycle be improved and discuss the factors limiting the use of these improvements.