Ph.D. Qualifying examination

Thermodynamics

Spring 2019

Notes:

1. Duration: 2.5 hours

2. Open book (textbook provided during the exam), however no solutions books or notes allowed

3. Two problems (of equal value)

4. Calculator is allowed.

5. Laptops, cell phones, and similar internet-connected devices are not allowed.

Problem 1

An engine is operating in an environment with an ambient temperature $25 \pm 2^{\circ}$C. The temperature of the exhaust is measured at $530 \pm 5^{\circ}$C (95% confidence intervals). Based on this data alone, consider the following cases reported for the heat the engine receives from its surroundings Q_C, the heat it rejects Q_H, and the work W_{cycle}:

1. Q_H = 710 kJ, W_{cycle} = 397 kJ, Q_C = 304 kJ
2. Q_H = 641 kJ, W_{cycle} = 397 kJ, Q_C = 242 kJ
3. Q_H = 641 kJ, W_{cycle} = 397 kJ, Q_C = 196 kJ

For each of these cases, determine if the reported values are thermodynamically feasible. Explain your reasoning. Comment on the level of confidence for each conclusion.

Problem 2

In an gas turbine running at steady state, air enters the compressor at 0.95 bar and 22ºC and exits at 5.7 bars. The air then passes through a heat exchanger before entering the turbine at 1100K, 5.7 bars. Air exits the turbine at 0.95 bar. The compressor and turbine operate adiabatically. Assume that kinetic and potential energy effects are ignored. Determine the net work by the plant, in kJ per kg of air flow for:

1. the compressor and turbine operate without internal irreversibilities.

2. the compressor and turbine isentropic efficiencies are 82 and 85%, respectively.