MET 350: Thermal Applications

Test 2 Reflection

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1. Course Learning Objectives

This test serves as a comprehensive demonstration of my proficiency in the following course learning objectives:

- **Analyze Regenerative Rankine Cycles:** The core of the test involved evaluating a power cycle utilizing both open and closed feedwater heaters. This demonstrated my ability to perform mass and energy balances on complex steam power systems.
- **Evaluate the Impact of Feedwater Heaters on Thermal Efficiency:** By analyzing the cycle with and without the closed feedwater heater (as required by the failure analysis in Case B), I demonstrated an understanding of how regeneration improves the overall thermal efficiency of a power plant.
- **Property Determination using Steam Tables:** Successfully identifying state properties (enthalpy, entropy, and specific volume) across eight different points in the cycle confirmed my ability to use industry-standard thermodynamic data.

2. Comparison Against Solutions and Mistake Analysis

Comparing my submitted work to the solutions provided by Dr. Ayala shows a high level of accuracy in the fundamental setup, though a few numerical discrepancies were identified.

- **Successes:** My calculation for the mass fraction $y = 0.0972$ for the open feedwater heater was identical to the solution. My state identification and T-s diagram accurately reflected the state changes, particularly the extraction points at 0.8 MPa and 100 kPa.
- **Mistakes:** My final thermal efficiency was calculated at 35.8%, while the solution for Case A was 36.6%.
  - **The Mistake:** This discrepancy originated in the calculation of h_5 (the enthalpy at the exit of the second pump). I calculated h_5 as 420.46 kJ/kg, whereas the solution utilized a value closer to 417.44 kJ/kg.
  - **The Why:** This was likely due to a more conservative inclusion of pump work across a larger pressure gradient than what was intended in the idealized solution.
  - **How to Correct:** I should have verified whether the pump work for Pump 2 was to be neglected or if specific volume changes at that state required a more precise interpolation from the compressed liquid tables.
- **Advice for Next Time:** I would advise myself to clearly list all assumptions regarding pump work at the start of the calculations. Additionally, I would perform a secondary check on the "Failure Case" (Case B) to ensure the logic for bypassing the closed feedwater heater is explicitly shown in the energy balance.

3. Grade and Artifact Quality

- **Estimated Grade:** I would estimate a grade of 82/100.
- **Strengths:** The test is highly organized, with a clear purpose statement and well-labeled diagrams. The procedural logic for identifying states 1 through 8 is technically sound.
- **Weaknesses:** There was a minor numerical drift in the final efficiency compared to the solution, and the discussion of Case B (the failure scenario) could have been more robust in its comparison to the ideal case.
- **Quality Insight:** This artifact represents a professional-level approach to thermodynamic modeling. The use of clear source citations (Steam Tables, Lectures) and a structured "Design Considerations" section ensures the work is reproducible and easy to follow.

4. Comprehensive Discussion

a. Issues and Troubleshooting: One issue I encountered was correctly mapping the flow through the closed feedwater heater and the subsequent trap. I bootstrapped this by sketching a detailed component diagram to ensure the mass flow percentages (y and z) balanced at the mixing points.

b. Steps Taken: I began with state identification, followed by property determination using the saturated and superheated steam tables. I then performed the work and heat calculations. If I were to change the process, I would create a table for all enthalpies at the start to reduce the risk of transcription errors during the efficiency calculation.

c. New Concepts: I learned the concept of "Feedwater Heater Failure" and how it affects the Qin requirements of the boiler. It was interesting to see how the loss of a single component can drop the plant's efficiency significantly.

d. Engineering Application: Engineers in the power generation industry use these concepts to design and maintain utility-scale steam turbines. Understanding these cycles is critical for optimizing the heat rate of a plant.

e. Personal Application: I expect to use these skills when analyzing energy systems in industrial settings, where steam is often used for both power and processing.

f. Professional Importance: This knowledge is vital for any mechanical or energy engineer. Regeneration is a standard practice in modern power plants, and understanding it is non-negotiable for professional competence in the energy sector.

g. Future Use: I will use these skills whenever I need to perform an energy audit or a performance assessment of a thermal system to identify where energy is being wasted.

h. Application to Other Work: The mass balance techniques I used here have been directly applicable to my other fluid mechanics and thermal science coursework.

i. Success & Improvement: I feel I improved the most in my efficiency with the steam tables. At the start of the course, property identification took significant time; now, it is a streamlined part of my workflow.

j. Career Intersection: This course content is the foundation of energy engineering. My ability to model these cycles allows me to contribute to discussions regarding system efficiency and sustainability in a professional environment.

k. Time Management: I spent about 5 hours on this test. I organized the time by doing the property identification on Friday and the efficiency modeling on Saturday. Next time, I would spend more time on the failure analysis case (Case B) to ensure that part of the report is as detailed as the ideal case.