Project Proposal

Assessment of Fluids and Operating Conditions for Supercritical Heat Recuperation

General Information

Type:	Master Thesis (30 ECTS)
Laboratory:	Laboratory for Applied Mechanical Design (LAMD)
Supervisors:	K. Jacoby; Prof. J. Schiffmann
Location:	Neuchâtel (travel allowance offered)
Contact:	konstantin.jacoby@epfl.ch
Website:	https://www.epfl.ch/labs/lamd/

Background

Supercritical power cycles are poised to play a pivotal role in the global energy transition towards renewable energy sources, driven primarily by their higher efficiencies and increased energy density. In supercritical cycles, fluids operate at pressures and temperatures exceeding their critical points, exhibiting non-ideal behavior that makes the ideal gas law invalid. Supercritical fluids demonstrate significant real-gas effects, characterized by complex, non-linear thermophysical properties.

Figure 1: LAMD Designed Impeller

At conditions near the critical point, thermophysical properties—especially specific heat—exhibit large variations. These substantial changes complicate heat exchanger design and performance prediction. Furthermore, significant differences in thermophysical properties at the critical point are observed among various fluids. Analyzing these fluids and their respective thermophysical characteristics will identify which fluid properties are most favorable for efficient operation in a recuperative cycle.

Operational parameters also critically influence recuperative cycle performance. Pressure ratio (PR) directly affects fluid expansion and compression, impacting cycle efficiency. Turbine inlet temperature (TIT) influences thermal efficiency and power output, balancing performance and material durability. Heat exchanger pinch temperature dictates heat exchanger effectiveness and overall system cost, while recuperation efficiency reflects the cycle's ability to reuse thermal energy.

Managing pressure drops is also essential to minimize energy losses. Understanding these parameters will significantly advance the development of efficient and effective supercritical recuperative cycles.

Objective

To investigate how the thermophysical properties of various fluids, as well as key cycle operating parameters (PR, TIT, pinch temperature, etc.), impact heat recuperation and overall cycle performance.

Tasks

1. Conduct a literature review of supercritical recuperative cycles.

2. Analyze the effects of recuperation parameters (pinch temperature, recuperation efficiency, pressure ratio, turbine inlet temperature, and cycle inlet conditions) on cycle performance and heat recuperation magnitude. (A pre-developed cycle modeling tool will be provided for student use.)

3. Perform a heat transfer analysis emphasizing the heat load capabilities of different supercritical fluids.

4. Identify fluids capable of effectively recuperating significant proportions of waste heat using an Extended Corresponding States (ECS) model. (An ECS modeling tool will be provided for student use.)

NB: adjustments may be required according to progress, results, and project duration.

Prerequisite knowledge

1. MATLAB
2. Heat Transfer
3. Thermodynamics