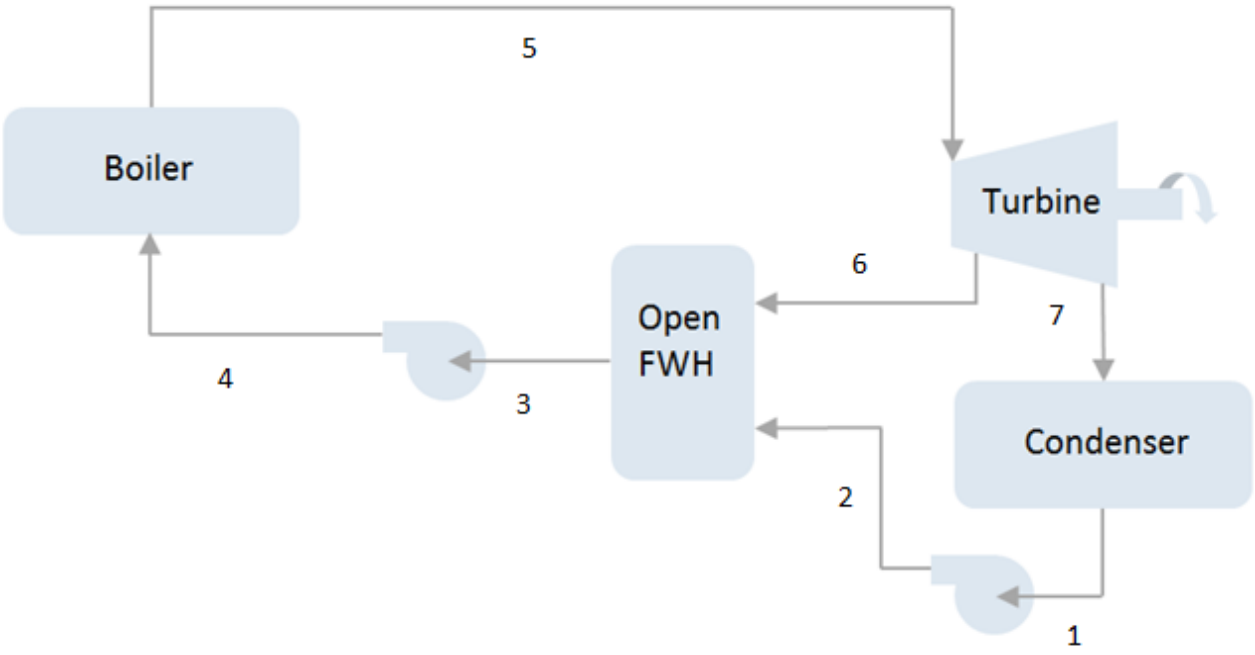
Optimizing the Efficiency of a Regenerative Rankine Cycle

Introduction

Rankine cycles are a thermodynamic process that turn heat into mechanical work. They are often employed in generating electrical power, with high pressure steam used to rotate a turbine.

The thermodynamic efficiency of a Rankine cycle is $\eta = \frac{W_{net}}{Q}$, where W_{net} is the net work done by the system, and Q is the heat added. Operating parameters are chosen to maximize efficiency - these may be the temperatures or pressures at various points in the system.



In this application, we will

- define a procedure that calculates the cycle efficiency as a function of the pump outlet pressures at points 2 and 4
- and then find the pump outlet pressures that maximize the efficiency of the cycle.

Thermal Efficiency of a Rankine Cycle

This Code Edit region contains a procedure that calculates the cycle efficiency as a function of pump output pressures. The procedure calculates

- the enthalpies, entropies, specific volumes and temperatures at every point,
- the fraction of water removed at the high and low pressure turbine extraction points,
- and the work done by the pumps.

The procedure can be modified to return any of these values; right now, it only returns the efficiency.

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Procedure to Calculate Efficiency as a Function of Pressures at
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Hence if both pumps output at 10^5 Pa, then the cycle efficiency is

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> η(10^5, 10^5)
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$$0.2107458916 \qquad \textbf{(2.1)}$$

Optimization

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> Optimization:-Maximize('η'(P2, P4), initialpoint = {P2 = 10^5, P4 = 10^5}, method
      = nonlinearsimplex, evaluationlimit = 300)
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$$\left[0.471565463928107165, \left[P2 = 2.12225630088669\,10^{6}, P4 = 3.342410798898\,05\,10^{7}\right]\right] \qquad \textbf{(3.1)}$$