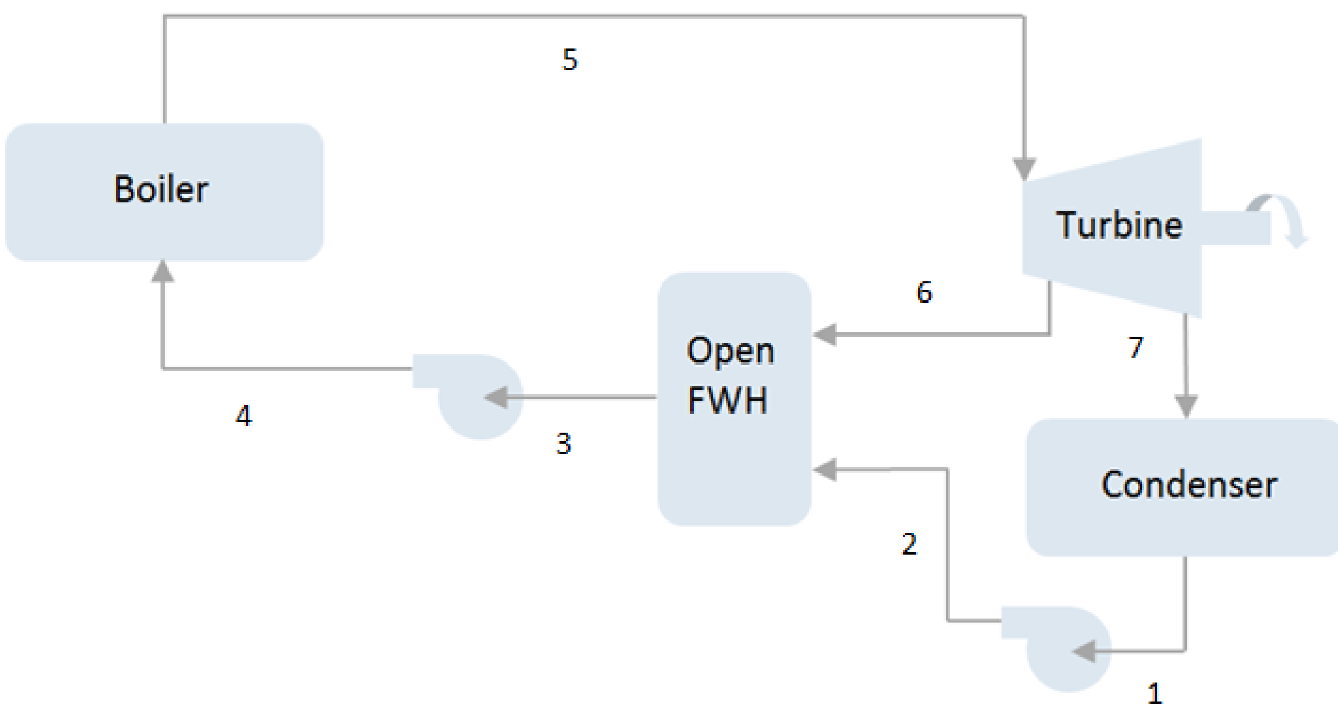
Maximizing the Efficiency of a Regenerative Rankine Cycle

Introduction

Rankine cycles are a thermodynamic process that turn heat into mechanical work. They're 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.

A typical regenerative Rankine cycle is illustrated below.



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.

> *restart*

Cycle Efficiency

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.

`Procedure to Calculate Efficiency as a Function of Pressures at Po`

Hence if both pumps output at 10^5 Pa, then the cycle efficiency is

> $\eta(10^5, 10^5)$

$$0.2107458916$$

Optimization

> $Optimization{:-}Maximize\left(\text{'}\eta\text{'}(P2, P4), initialpoint = \{P2 = 10^5, P4 = 10^5\}, method = nonlinearsimplex, evaluationlimit = 300\right)$

$$[0.471565463928086515, [P2 = 2.12225630088669\ 10^6, P4 = 3.34241079889805\ 10^7]]$$