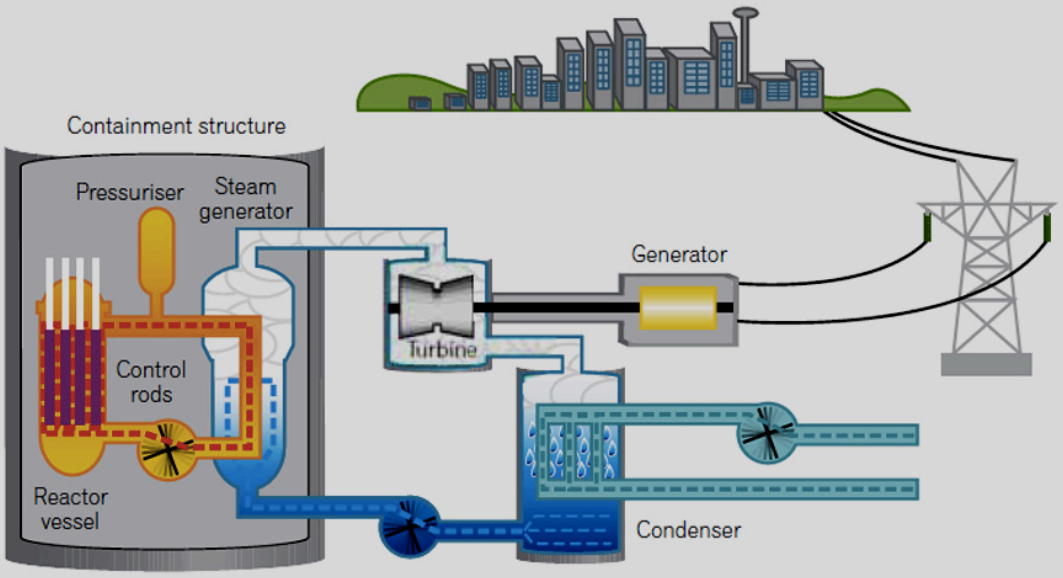
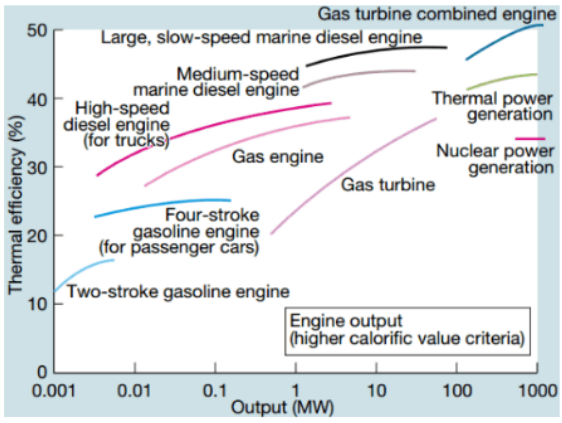
Figure 1 Schematic of a pressurised water reactor



Source: United States Nuclear Regulatory Commission (NRC)

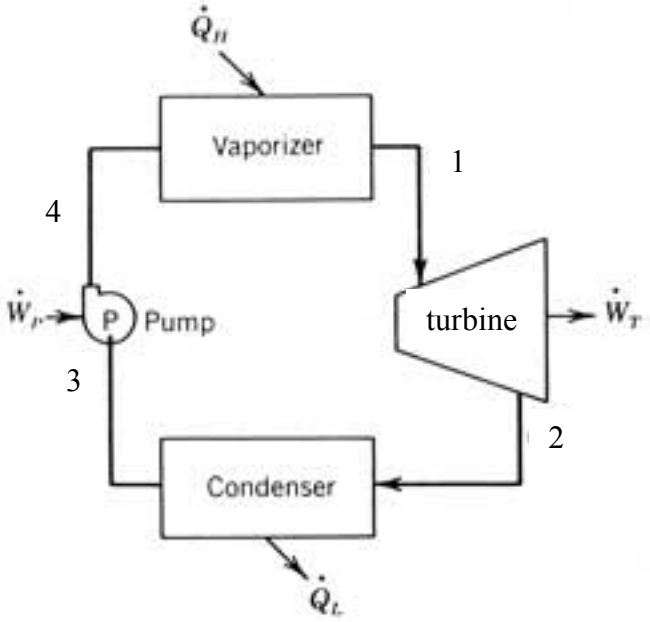
ME 200 (Thermodynamics I)
Lecture 33

The Rankine Cycle



Takaishi, Tatsuo; Numata, Akira; Nakano, Ryouji; Sakaguchi, Katsuhiko (March 2008). "Approach to High Efficiency Diesel and Gas Engines" (PDF). Mitsubishi Heavy Industries Technical Review. 45 (1). Retrieved 2011-02-04.

The Rankine Cycle



1st Law applied to the turbine:

1st Law applied to the pump:

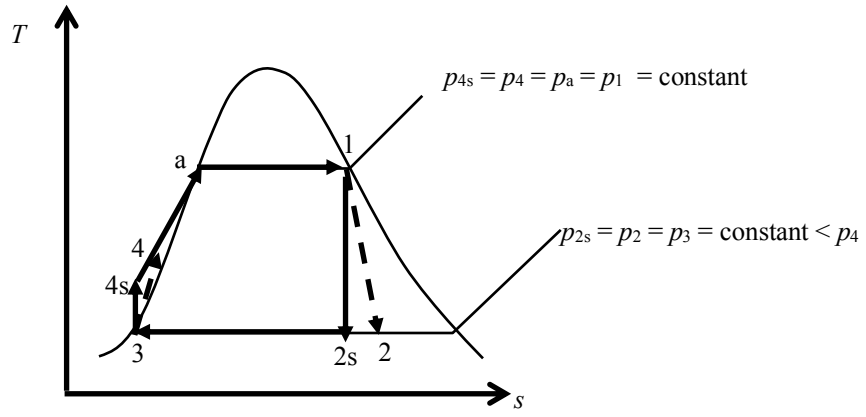
1st Law applied to the boiler/vaporizer/steam generator:

1st Law applied to the condenser:

Thermal efficiency of the power cycle:

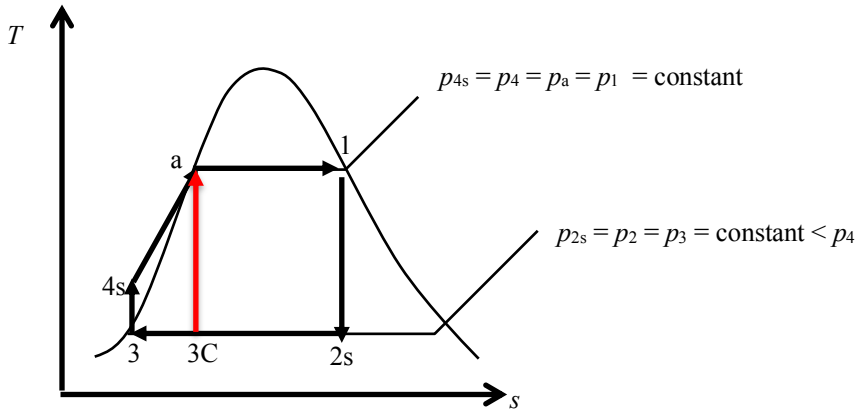
<u>Ideal</u> Rankine Cycle

Process 1 – 2s: isentropic expansion of the working fluid from saturated vapor through the turbine
Process 2s – 3: heat transfer from the working fluid as it flows at constant pressure through the condenser to a saturated liquid state
Process 3 – 4s: isentropic compression of the working fluid in the pump in the compressed liquid region
Process 4s – 1: heat transfer to the working fluid as it flows at constant pressure through the boiler



Notes

1. The thermal efficiency of the power cycle increases as the average temperature at which the heat is added in the boiler increases and the average temperature (or pressure) at which the heat is rejected in the condenser decreases.
   a. A Carnot cycle has a larger thermal efficiency than an ideal Rankine cycle since the average temperature at which heat is added in the boiler is smaller for the Rankine cycle due to the path from 4*s*-a-1.



Carnot cycle: 1-2s-3C-a
Ideal Rankine cycle: 1-2s-3-4s-1

   b. Increasing the average temperature at which heat is added may be achieved by increasing the boiler pressure or by moving State 1 into a SHV phase. Increasing the boiler pressure can be costly due to the increased stress on the pipe system; however, moving State 1 into a SHV phase is relatively easy. Moving into the SHV region is known as a Rankine Cycle with Superheat.
   c. The lowest possible condenser temperature/pressure corresponds to just larger than the conditions of the surroundings since this is the where the heat is being rejected. (Recall that heat is transferred from a hotter object to a colder one.)