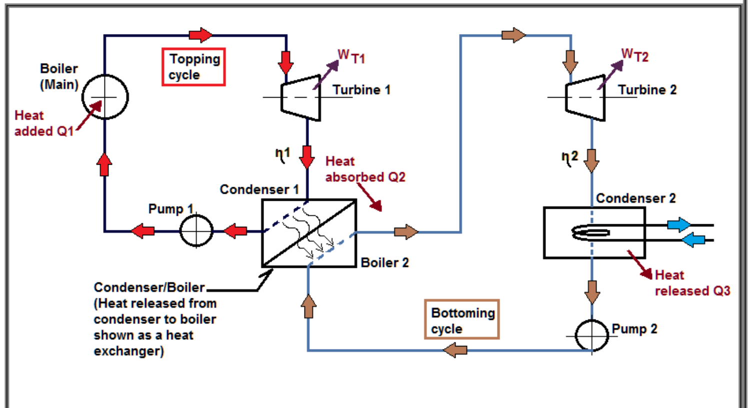
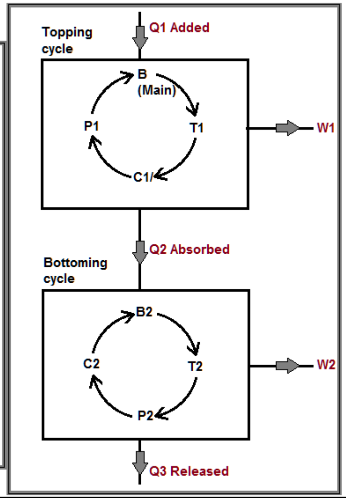
Combined Cycle Power Plant.



Two vapour power cycles coupled in series.



Explanation: If we can find a liquid which has a higher boiling point than water, much higher, could we then direct the heat passing through the first turbine into a heat exchanger, part condenser part boiler, that could heat water to steam at super heated values? Yes! There was a major plant put in operation in the 1950's that used mercury as the top cycle fluid and water the bottom cycle fluid. There were similar small scale plants in the 1920's.

Mercury higher boiling point than water. Not a new technique. However mercury is not readily available. There are other fluids used for the top cycle.

This is an example of a combined cycle power generation.

Coupled cycles (Rankine - Rankine cycles).

When two cycles (type basic Rankine cycle) are coupled in series, the heat lost by one cycle is absorbed by the other cycle. One early example is the mercury (top) and steam (bottom) cycles.

n1: efficiency of the top cycle.
n2: efficiency of the bottom cycle.

n1: 1 - (Q2/Q1) - typical thermodynamic efficiency equation without consideration of losses.
n2: 1 - (Q3/Q2).

Rearranging,
$Q2 = (1-n1)\,Q1.$
$Q3 = (1-n2)\,Q2.$

n: the overall efficiency of the system.

$n = 1 - (Q3/Q1).$
$\quad = 1 - ((1-n2)\,Q2) / Q1.$
$\quad = 1 - (Q1(1-n1)(1-n2)) / (Q1).$
$n = 1 - (1-n1)(1-n2).$
Rearranging,
$1 - n = (1-n1)(1-n2).$

Thus logically for n cycles coupled in series, the overall efficiency is

$1 - n = (1-n1)(1-n2)(1-n3).....(1-n_n).$

$1 - n = {}^{n}\sum_{i=1}(1-n_i).$
Rearranging,
$n = 1 - {}^{n}\sum_{i=1}(1-n_i).$

More than two cycles are not considered because the system becomes complex, and costly. This is a binary system, since 2 cycles (Rankine) are considered.

Binary cycle efficiency?

$n = 1 - (1-n1)(1-n2) = 1 - (1 - n2 - n1 + n1n2)\,.$
$n = n2 + n1 - n1n2.$
$n = n1 + n2 - n1n2$ - binary cycle efficiency.

If the efficiency of a mercury cycle was 0.41, and efficiency of the steam cycle was 0.51.
The overall system efficiency of the plant without losses taken into consideration is:

$n = 0.41 + 0.51 - (0.41 \times 0.51).$
$n = 0.7109.$

This is better efficiency compared to a single fluid steam power plant.

Multiple fluid coupled cycles in series are more efficient than single fluid systems and they provide fuel savings. Investigate with existing steam power plants operating in your vicinity on the combined cycle savings.

Series connection of the binary system is shown visible in the figure 'Two vapour cycles coupled in series'. Following the fluid path in a detailed diagram reveals their series connection through the boiler system (Eco-SH-Boiler Drum).

Completion of world's largest combined cycle power plants in record time

- Plants add up to 14.4 GW capacity to Egypt's national grid
- Enough power to meet the electricity needs of over 40 million people
- Helping the country save over $1 billion annually on fuel costs

In collaboration with the Egyptian Ministry of Electricity and Renewable Energy, Siemens and its consortium partners, Orascom Construction and Elsewedy Electric, announced today the completion of the Egypt Megaproject in record time. The parties celebrated the combined cycle commissioning and the start of operations at the Beni Suef, Burullus and New Capital power plants. The stations will add a total of 14.4 gigawatts (GW) of power generation capacity to Egypt's national grid, enough power to supply up to 40 million people with reliable electricity.

With this milestone, Egypt, Siemens and the company's consortium partners have set a new world record for execution of modern, fast-track power projects, delivering 14.4 GW of power in only 27.5 months. A single combined cycle power plant block with a capacity of 1,200 megawatts typically takes approximately 30 months for construction. For the Egypt Megaproject Siemens in parallel built twelve of these blocks in record time and connected them to the grid. Now, each of the three 4.8 GW-power plants has become the largest gas-fired combined cycle plant ever built and operated in the world.