All steam power plants are based upon the ideal Rankine cycle shown below.

The four devices are
- Constant Pressure Boiler
- Isentropic Turbine
- Constant Pressure Condenser (fluid exits as saturated liquid)
- Isentropic Pump

In actual steam power systems, two additional devices are often included to improve performance and efficiency of the system: re heater and feedwater heater. Both of these are discussed below.

1. Reheater: In analyzing ideal Rankine cycle performance it is seen that the large the pressure drop across the turbine the higher the thermal efficiency of the cycle. However, as the pressure drop rises the quality of the steam leaving the turbine decreases. This is a major problem since if we consider the "wet" steam to be composed of small droplets suspended in a gas (vapor), one could imagine these small droplets impacting on the turbine blades and causing considerable erosion and mechanical fatigue. In fact, most modern turbines can only withstand an exit quality greater than 95%. To work within in this constraint one needs to either lower the pressure drop (which will decrease the thermal efficiency), increase the inlet steam temperature, or apply reheating. For a variety of reasons the preferred
choice is often to employ a reheat leg. In a reheat leg the steam is not expanded all at once to the condenser pressure, but rather is expanded part of the way, staying within the exit quality constraint of the turbine, in the high pressure turbine, then reheated by passing it for a second time through the boiler (the reheat leg), and finally is expanded the rest of the way through a second turbine, the low pressure turbine. A block diagram of a Rankine cycle with reheat is shown below:

To evaluate the reheat leg both its pressure (which will remain constant) and its exit temperature (which will often be very close to the exit temperature of the steams first pass through the boiler) must be specified. There is no work associated with the re heater device, but the heat transfer in can be calculated as

\[ \dot{Q}_{\text{reheat}} = \dot{m}(h_{\text{out}} - h_{\text{in}}) \]

When the thermal efficiency is calculated for the plant this heat must be included in the heat added term, or for a number of reheaters the heat added will be the sum of the boiler heat transfer and all the re heater heat transfers,

\[ \dot{Q}_{\text{in}} = \dot{Q}_{\text{boiler}} + \sum_{i} \dot{Q}_{\text{rh},i} \]
2. Feedwater Heater: In the ideal Rankine cycle saturated liquid leaves the condenser and is compressed by the pump to a high pressure liquid prior to entering the boiler. If the pressure boost is large, a considerable amount of subcooling occurs. Then as this subcooled liquid enters the boiler a considerable amount of energy must be expended to simply raise it to the boiling point. In an attempt to decrease this energy, it is proposed to do the pumping in stages and then to heat the subcooled liquid so as to bring it up to the saturation temperature. This heating is done in what we call feedwater heaters. The heating occurs by extracting some steam from a turbine and using it to heat the subcooled water. This is accomplished in one of two ways: either using a traditional heat exchanger called a closed feedwater heater or a direct contact heat exchanger where the subcooled liquid and extracted steam are allowed to mix called an open feedwater heater. In an open feedwater heater we really have a mixing chamber in which the extracted steam at some pressure is mixed with condenser water whose pressure has been increased to the extracted steam pressure by a pump. A block diagram of a Rankine cycle with a single open feedwater heater is shown below

![Block diagram of a Rankine cycle with a single open feedwater heater](image)

The constraint of saturated liquid leaving the open feedwater heater will require that a certain amount of steam be extracted from the turbine for the feedwater heater. This mass can be determined by applying the first law to the feedwater heater

\[ \dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3 \]

and the conservation of mass
\[ \dot{m}_1 + \dot{m}_2 = \dot{m}_3 \]

where the subscripts refer to the diagram below.

The two equations above have two unknowns, \( \dot{m}_1 \) and \( \dot{m}_2 \), that can be readily solved for

\[ \dot{m}_2 = \dot{m}_3 \frac{h_3 - h_1}{h_2 - h_1} \]

For a system with more than one feedwater heater we first solve for the mass flows associated with the highest pressure heater and then move on to the next highest pressure heater and so on.

In summary, we may modify our simple Rankine cycle with the addition of reheating and regeneration which results in two new devices

Reheat Leg: Constant pressure device with no work, only heat transfer.
Open Feedwater Heater: Constant pressure device with no work or heat transfer and the fluid leaves as saturated liquid,