Closed Loop Steam Turbine

Background:

A thermal power station converts heat energy to electrical energy. In thermal power plants closed loop steam driven turbines are extensively used. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated initially. This is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different heat sources, fossil fuel dominates here, although nuclear heat energy and solar heat energy are also used. In addition to generating electrical power, thermal power plants are also designed to produce heat energy for industrial purposes of district heating, or desalination of water.

Description of flowsheet:

Steam at 8kg/s enters the adiabatic turbine at 500 degree Celsius and 10000kPa pressure and runs the turbine. The turbine operates at 75% efficiency and generates about 19858kW of power output. The expanded steam exits the turbine at 60 degree Celsius and 20kPa pressure. This steam is further cooled to 40 degree Celsius where 6684kW of energy is extracted. Now the steam has condensed to water and is recycled again. This water output from the cooler is pumped to a boiler with an increase in pressure back to it feed pressure of 10000kPa. The pump used has 75% efficiency. Now the water which enters the boiler at elevated pressure is again heated up to 500 degree Celsius to get back the initial steam feed conditions. The energy input for the heater is 26441kW which is used up to boil it to the feed conditions. Now this steam output from the boiler is fed to the adiabatic turbine to complete the closed cycle steam turbine system.

Results:

The following results are readily calculated by DWSIM

1) 26441kW of energy input is required for the boiler.

2) The pump requires 101kW of energy input.

3) The total energy input is 26542kW.

4) The energy output from the adiabatic turbine is 19858kW and from the cooler is 6684kW.

5) The total energy output is then 26542kW.

Conclusions:

1) The required energy input to boil the water and get required steam is obtained by combustion of fossil fuels or other various methods is effectively converted to shaft work which is converted to electrical energy.

2) The cooler used can be a heat exchanger where the output energy calculated will be used to heat the inlet cooling fluid into the exchanger.

Reference:

https://www.ohio.edu/mechanical/thermo/Intro/Chapt.1_6/Chapter4b.html